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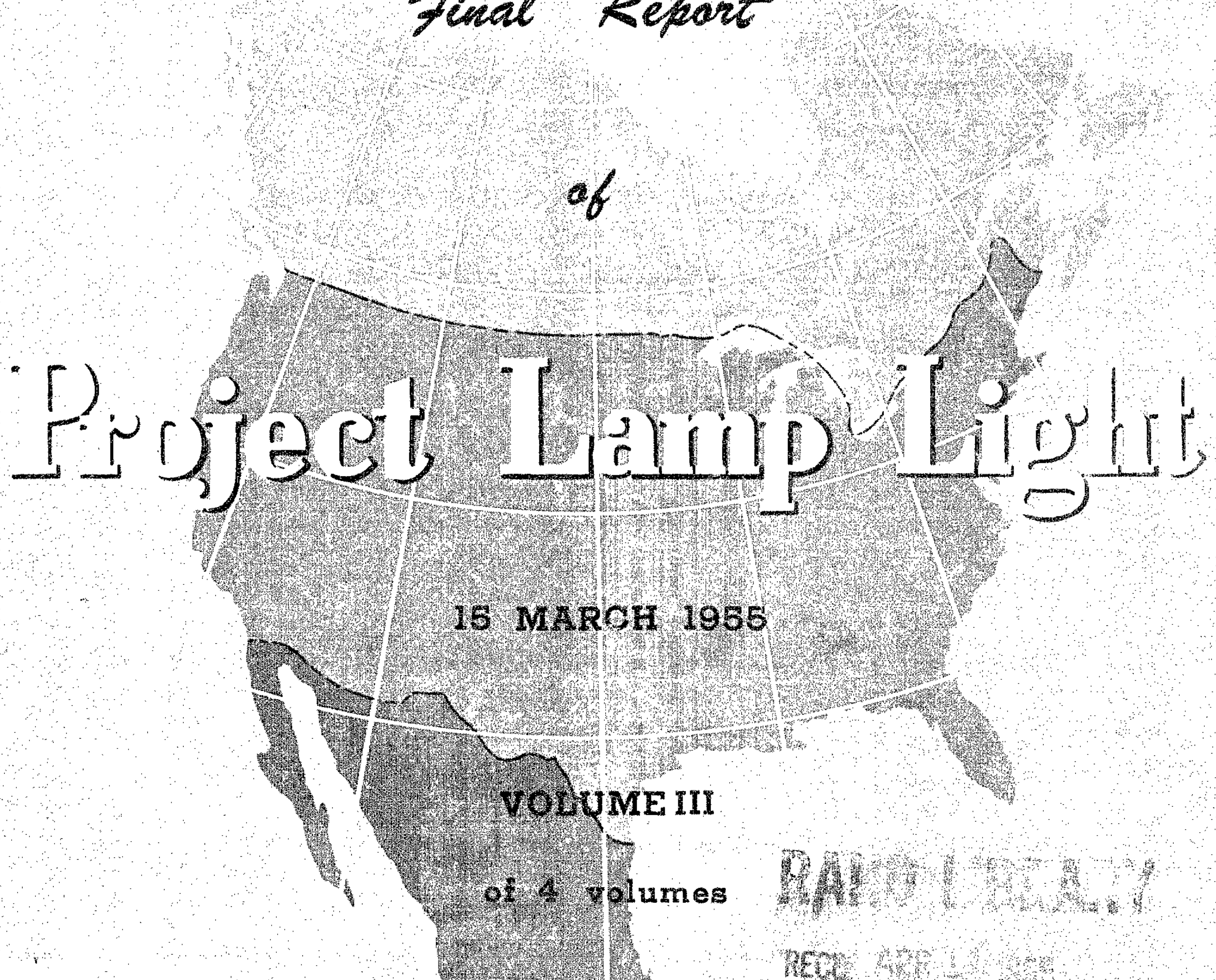
DEFENSE OF NORTH AMERICA

Final Report

of

Project Lamp Light



15 MARCH 1955

VOLUME III

of 4 volumes

N5-ORI-078 TASK ORDER 90

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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Defense of North America

Final Report

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CAMBRIDGE MASSACHUSETTS

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Summary

INTRODUCTION

Air defense is a major element of our national security. The Soviet atomic explosion of 1949 and the wars in Korea and Indochina have created insistent demands that we improve the protection of our strategic air bases and urban centers against air attack. Evidence of Soviet progress in thermonuclear weapons and long-range jet aircraft has highlighted the urgency of the situation.

Advances in our air defense system have been made in several important directions. The aircraft control and warning net has been expanded and modernized; identification procedures have been tightened; we have more interceptor squadrons equipped with better aircraft and more lethal weapons; local defenses have been strengthened. The Continental Air Defense Command's program looks to the further systematic improvement of these capabilities.

The main problem now before us is the outward extension of this system. The best air defense would be the complete destruction of the enemy's aircraft on their home bases prior to takeoff. Since we cannot hope to achieve this, we must create a defense system of such depth that early warning is given of approaching hostile bombers, that they are continually harrassed during their approach, and that they are intercepted and destroyed before they reach their targets in North America.

Outward extension of the existing defenses is required with particular urgency for the ocean approaches to our important cities on the Atlantic and Pacific Coasts. A precision data zone suitable for intercept control is to be established with radars on Texas Towers, picket ships, and AEW aircraft. This contiguous zone, several hundred miles in depth, must be designed as an extension of the continental SAGE System. The compatibility of the continental

Summary

system with the naval forces extending it seaward, and the related mechanization of data handling, were the specific problems that led to the formation of Project Lamp Light. Communications are a crucial factor in the solution of these problems.

Outside the contiguous data zone, a somewhat different type of surveillance is obtainable from merchant shipping. While not suitable for interceptor control, properly coordinated information from this source would be extremely valuable.

To obtain the earliest possible indication of air attack, early-information lines are required in addition to general surveillance. The first distant line of this type is the DEW Line in the Far North, scheduled for operation in 1957. Plans are under study to extend this line by surface stations on land, ice and sea, and by AEW aircraft.

The information obtained by these techniques in the remote zone is different in kind from the precision data cover provided in the contiguous zone or over fleet units. Interception and combat in the remote zone would require interceptor aircraft of very long range, equipped with large search radars. Guided only by the early-information net, these aircraft would take off from distant bases, use their own radars to find the enemy, and attack with long-range air-to-air missiles.

The air threat to our national security is paralleled by a seaborne threat directed against our coastal targets and lines of communication. Information to counter this threat is derived from the systematic surveillance of surface traffic as well as from submarine-detection systems. We must find techniques of combining air and sea surveillance functions in naval operations wherever this can be done without sacrificing good performance.

Summary

Within the general problem area that has been outlined here, Project Lamp Light has studied component technology as well as complete systems.

Defense against intercontinental ballistic missiles has not been considered by Lamp Light; this important problem is currently in the hands of a special committee of the USAF Scientific Advisory Board. Nor have we studied the enemy's possible use of nuclear propulsion for his aircraft, since it is unlikely to change our general method of defense for the period 1955-1960.

AEW RADAR (see chapter 2)

OCEAN AREAS

To extend our defense perimeter outward over the sea and into the arctic, we must learn to use aircraft as platforms for large search radars. The AEW missions of today are severely limited by clutter whenever the sea is rough; we urgently need better radars for our ocean patrols. Larger antennas, higher power output, and a more judicious choice of frequency will help. By using interim conversions, we can improve the performance of search radars and height finders within the next few years. A parallel long-term program will enable us, between 1958 and 1960, to install high-power radars of advanced design on search aircraft carrying 30-foot antennas. Over the sea, we shall then have reliable search ranges of 200 miles on medium jet bombers at all altitudes.

LAND AREAS

Over land, the radar search problem is much more difficult. No complete solution of the clutter problem is in sight at present. We need, first of all, reliable measurements of land clutter over northern Canada, Greenland, and the polar ice fields. We can then embark on a determined research and development effort toward the equipment we badly need for AEW operations over those regions.

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HEIGHT FINDERS

To obtain height data on all targets within the AEW search range, we must keep height-finder improvement in step with the search-radar program. In the search aircraft of 1960, a UHF search radar can be teamed up with an S-band stacked-beam radar to provide simultaneous search on two frequencies as well as height information.

AI RADAR (see chapter 3)

AI radar is the crucial element of the air defense battle during that brief interval in which the interceptor must position itself for weapon release with higher precision than ground control can provide. For rocket armament, this calls for lock-on ranges of 10 miles; for missile armament, 15. At altitudes below 5000 feet, existing radars fall far short of these ranges. The resulting low-altitude gap is one of the outstanding defects of our air defense system; research and development to close it must be regarded as imperative.

The only available interim solution is the APG-43 continuous-wave radar; maximum effort is justified to have this set in operation soon. Ultimately, we need S-band radars with antenna apertures larger than 40 inches. Pulse-Doppler systems look promising and deserve full exploration.

SURFACE-TO-AIR RADARS (see chapter 4)

The large ground- and ship-based search radars which will provide most of the data for the air defense battle can be expected to perform well, so well indeed that the enemy will try to blind them by jamming. In this he will easily succeed. We must make it far more difficult for him in the future. By using a wide diversity of frequencies, we can compel the enemy to carry a large complex of jammers and to spread the available power over a wide spectrum. Having thus reduced the effective jamming power against each radar, we can build radars of extreme power and large antenna size which retain limited

capability even in the presence of jamming. Finally, we must develop techniques for correlating azimuth and height information from different sites so that we can determine the position of the jammers after radar echo ranging becomes impossible.

FLUTTAR DETECTION SYSTEMS (see chapter 5)

Fluttar is a system for the detection of moving targets that cross a line between a transmitter and a receiver geographically separated from each other. Such a system provides information complementary to that derived from radar. The two systems can be combined into an excellent data source for target detection, flight evaluation, and complete early-information cover.

Fluttar yields characteristic visual and aural target records - "Fluttar-prints" - by which different aircraft may be distinguished and a flight of two or more aircraft recognized. Used with radar on early-information lines, Fluttar can add low cover and target recognition and be particularly helpful in bridging difficult water gaps such as the Davis Strait.

COMMUNICATIONS (see chapter 6)

REQUIRED LINKS

Reliable communications are a vital factor in adequate air defense. They are needed between air and ground, both within and beyond the line-of-sight. They are needed from ship to ship and between ships and shore stations. They are needed as point-to-point relays between different ground stations.

The data-processing systems proposed for fleet units engaged in air defense or antisubmarine operations impose special demands on communications. The facilities now available to the fleet cannot properly meet these demands.

Summary

NEW TECHNIQUES

By proper application of new techniques and better utilization of existing facilities, we believe all military communications problems can be technically solved, provided that no unreasonable or unnecessary demands are made.

LINE-OF-SIGHT

The capacity of the present short-range communication system is restricted by interference between channels. A new system of multiplexing by means of time-sharing is proposed in this report under the designation Centipede. This system will provide voice and data transmission for a large number of networks on a single radio-frequency channel.

BEYOND-THE-HORIZON

The new scatter modes of propagation such as meteor forward scatter, ionospheric scatter and tropospheric scatter, provide means of solving the beyond-the-horizon transmission problem that are much more reliable than the usual ionosphere-reflected signals.

DATA PROCESSING (see chapter 7)

OBJECTIVES

Modern techniques of data handling and data processing are essential to the Navy's role in continental defense, and offer a major opportunity for increasing the effectiveness of the fleet. The present manual methods of handling data on board ship are slow, inaccurate, and are saturated by a few tracks. Well-designed data processing is the key to greatly increased single-ship capacity, rapid exchange of data among ships in a fleet, and compatibility with the shore system.

TIME SCALE

We therefore believe that the U. S. Navy should have a modern data-processing system at the earliest possible time. Because it will take more than two years to get a high-performance digital system, we are forced to conclude that two systems must be programed:

Summary

Phase 1: An analogue system for installation beginning in 1957;

Phase 2: A digital system for installation as soon as it can be developed and produced, and not later than 1960.

EDS AND DATAR

For Phase 1, the Electronic Data System (EDS) designed at the Naval Research Laboratory meets the most important interim requirements in the fleet and in sea picket ships assigned to continental defense.

For Phase 2, the Canadian Datar System is, in our opinion, the best starting point for a research, development, and production program aimed at 1960 delivery of high-performance digital data-processing systems.

RESEARCH

A continuing program of research is needed to determine the relative advantages of general-purpose computers, special-purpose computers, and combinations of both, for data processing in the fleet.

RELATED EQUIPMENT

Air defense information from picket ships is to be transmitted to a shore station equipped, initially, with a commercially available general-purpose computer, later with modified SAGE equipment.

Together with related data-processing equipment in AEW aircraft and with suitable communication links, this program will provide capacity, speed, and flexibility commensurate with the input detection devices and the weapons that are likely to be available.

Summary

IDENTIFICATION (see chapter 8)

FAIL-SAFE IFF

Atomic weapons have given a new importance to the problem of identifying friendly and hostile aircraft. We must face up to the need for a reliable IFF system, a system that makes it impossible for an enemy bomber to appear as a friendly aircraft. The system must fail-safe: the lives of one million civilians cannot be jeopardized to save one pilot whose equipment is defective.

COLD WAR IFF

In the cold war period, adequate procedural identification can be achieved by the gradual improvement of navigation, discipline, and the installation of CAA safety beacons.

HOT WAR IFF

In a hot war, it is vital to have secure electronic IFF in addition to procedural identification. Our present Mark X IFF and its SIF modification are not secure and are therefore dangerous. An insecure IFF system is worse than none. A secure system is feasible; its secret element must be the code key, not the equipment. The development of such a system is a matter of high urgency.

ALLIED AIRCRAFT

It is essential to our defense that U.S. and allied aircraft use the same IFF system. This can be done without risk of compromise if we rely on code secrecy rather than equipment secrecy.

PRIORITIES

IFF development has been hampered by unwarranted confusion between IFF and beacon functions. The most urgent problem is to prevent hostile bombers from masquerading as our own aircraft. We shall also want to protect friendly aircraft from unauthorized interrogation, but this is a secondary objective.

Summary

DEFENSE AGAINST ELECTRONIC COUNTERMEASURES (see chapter 9)

ECM THREAT

An enemy determined to paralyze our air defense will concentrate his efforts on the electronic devices that constitute its nerve system. His megaton bombs make it easy for him to assign a large fraction of an invading bomber force to the task of disabling our radars and our communications. He can limit our radars to one-tenth of their normal range. He can mislead us concerning the size of his raid. He can cause our radars to report so many spurious targets that the data-handling system will be saturated. He can jam our communications and navigation systems so that interceptors will have no guidance outside the range of their own AI sets. He can interfere with the control and fuzing of our missiles.

COUNTER-ECM

To prevent a catastrophic breakdown of our defenses, we must train our men to operate in the face of intensive countermeasures, we must protect ourselves by frequency diversity and extreme power, and we must adopt numerous specific techniques designed to reduce, by their cumulative action, the vulnerability of our radars, our communications, and our weapons. We can never afford to lose sight of the fact that the enemy's electronic countermeasures are his cheapest weapon against our air defense system.

ELECTRONIC WARFARE

It is doubtful whether we can improve our radars and communications to the point where the enemy will find it wholly useless to attack with countermeasures. But we can and must learn to use the radiation from an airborne jammer to bring about the destruction of its carrier. This calls for passive ground techniques for direction finding, homing indicators for interceptors, and, above all, missiles that home on jammers. If by vigorous exploitation of these means we

Summary

can convince the enemy that jamming radiations are a more serious danger to him than to us, we shall have gained the upper hand in the electronic war.

AIRCRAFT AND WEAPONS (see chapter 10)

AIR-TO-AIR MISSILES Provision of air-to-air missiles with small nuclear warheads (a few kilotons' yield) in ample supply and considerable variety of guidance, range and size seems the only simple method of preventing raids of unfortunate compactness, and raids that fly at extremes of height and speed. Such nuclear-warhead weapons must have jump-up capability and speed to enable the launching interceptor to make a reasonably safe attack. No other known type of air-to-air weapon can be expected to be a satisfactory substitute for them. The quantity of small nuclear warheads that are required (numbered in the thousands) seems to be in every way reasonable.

Air-to-air homing or guided missiles must make up for the inability of an interceptor to maneuver at the heights and speeds required for the interception of bombers. This ability must be reflected in their speed, range, jump-up capability and in their control. The closing phase of a homing missile's course is far less susceptible to countermeasures or evasion than almost any other part of the total air defense system. The easiest point of view to adopt is that the interceptor is a missile launching platform with modest capability.

SURFACE-TO-AIR MISSILES The major gap in the present planning for surface-to-air missiles lies in their inability to attack fast, high- or low-altitude, air-to-surface missiles. A careful systems study of the detection, acquisition, tracking and control problems is required. It has not been possible to include this in Project Lamp Light.

Summary

MISSILES THAT HOME ON JAMMERS

The lack of a weapons system that exploits jamming transmissions by enemy bombers is one of the most important gaps in the present U.S. air defense plans. It seems possible to determine the time appropriate to launch an air-to-air homing missile by range determinations that involve only passive observations. Once launched, a missile that seeks its prey by purely passive measures seems difficult to jam or evade, provided the aircraft carrying the jammers are separated by a few miles, as they would be if some of the interceptor weapons available were atomic-warhead types. We seek conviction on the part of an enemy pilot that his jamming transmitter is the beacon that assists him in his own destruction.

SYSTEMS DESIGN OBJECTIVES (see chapter II)

BASIC DEFENSE CONCEPT

The Lamp Light Study has been governed by the general concept of national defense enunciated by responsible officials of the United States. Under this concept, we rely for defense basically and primarily on the deterrent effects of a long-range air force, designed to exploit the power of nuclear weapons, and of a strong tactical air force, also equipped with nuclear weapons and deployed according to plans for a common defense of the entire western world.

AIR DEFENSE FORCE

A third force, based on and around North America in accordance with a joint United States-Canadian plan, is designed for defense and consists primarily of local defense weapons, manned and unmanned interceptors, and electronic facilities.

The outward extension of this air defense force has been the principal subject of Project Lamp Light. This problem involves the design of the air defense system as a whole, and the analysis of modifications intended to improve its performance.

Summary

AIR THREAT

The first consideration in designing an air defense system is the threat against which the system is intended to protect our country. We have assumed that before 1960 the Soviet Union will be capable of staging an all-out massive air attack against North America. We consider such an attack more dangerous than the sneak attack in which a few aircraft penetrate the air defense system. We visualize TU-4, Type 39, and Type 37 aircraft in the quantities discussed in the National Intelligence Estimates. While we must be prepared for invasion at altitudes up to 60,000 feet, we cannot dismiss the threat of low-altitude penetration. By 1960, we believe a 100-mile air-to-surface missile will be available to the enemy. We have assumed that weapons of megaton yield would be used in such an attack and that the bomb carriers would be accompanied by similar aircraft capable of intensive electronic countermeasure activity. We have given much attention to the simultaneous threat of large numbers of short- and long-range decoys. Lastly, we have considered the possibility that this entire air attack might be synchronized with the launching of guided missiles from enemy submarines and surface ships.

LEVEL OF DEFENSE

The objective of defense system design is to provide a level of protection adequate to this threat. This does not mean that the system will provide complete and absolute protection; it does mean, however, that the system will not collapse when faced with the assumed maximum threat. Such a system will not prevent hardship and injury to our country, but it will preserve our existence as a nation.

COST OF DEFENSE

We believe that an air defense system providing this level of defense is possible within budgets of the approximate magnitude proposed by the Air Defense Command for the 1955-1960 period. Systems design and evaluation were made within a narrow range of values around this level.

Summary

THE CONTIGUOUS AIR DEFENSE ZONE (see chapter 12)

THE LAMPLIGHT MODIFICATION

In exploring the possibilities of achieving more effective continental defenses than present plans will provide for 1960, Project Lamp Light was led to the design of a modified air defense system. This design calls for only moderate changes in the quantities and deployment of the facilities and weapons now contemplated by the Air Defense Command in ADR 54-60.

COMBAT DEPTH

The outstanding feature of the Lamp Light system is a widening of the contiguous surveillance data zone around the defended areas. We propose that this zone extend out to 1400 miles for high-altitude targets, and 1000 miles for low-altitude targets. In this way, we shall widen the combat zone to about 700 miles, and thus make more effective use of the combat ranges of the interceptors that we shall have in operation by 1960.

Such a system will make it more difficult for the enemy to use saturation tactics against a narrow sector of our defenses. It will give us more time to break up large compact formations by continuous attack, and to destroy bombers before they launch decoys and air-to-surface missiles.

OCEAN APPROACHES

The necessary data over the ocean approaches are best obtained by a combination of AEW aircraft and picket ships. These vehicles are to be equipped for the detection and identification of aircraft, surface ships and submarines. They must be able to control air interception and thus provide combat control beyond the coverage of the SAGE System. Data-processing equipment and picket ships must allow efficient interchange of information from shore stations, AEW aircraft, and other fleet units.

Summary

VERY HIGH & VERY LOW ALTITUDES

The most serious problems in air defense system design occur at very high and very low altitudes. Against targets at 60,000 and 80,000 feet we shall need improved high-altitude missiles and air-to-air missiles with jump-up capability. Against low-altitude targets, including fast air-to-surface missiles launched from enemy bombers, we need effective surface-to-air defense missiles.

THE REMOTE AIR DEFENSE ZONE (see chapter 13)

The region that extends from the perimeter of the contiguous air defense zone to the territory controlled by the Soviet Union has been studied with two objectives in mind: (a) securing early information; (b) extending the area of possible combat operations.

EARLY INFORMATION

In remote regions, even a moderate degree of surveillance will deny to the enemy any large chance of proceeding far on his mission without coming under observation. To our own forces, the additional warning time that may be derived from early information is a major advantage.

METHODS

Two different methods are available for aircraft surveillance in a remote zone: (a) planned barriers (lines), so placed that even a single aircraft is likely to be detected upon crossing; (b) general surveillance extending over broad areas in which so many detectors are deployed that an enemy aircraft is unlikely to avoid them all.

BARRIERS

Sea-wing extensions by AEW aircraft and picket ships between Hawaii and Kodiak, and between Newfoundland and the Azores, will prevent end runs around the programmed DEW Line from Alaska to Baffin Island.

Better coverage and reliability can be obtained later by replacing some of these

Summary

patrols with land-based detection stations in the Aleutians, in western Alaska, and in Baffin Island, Greenland and Iceland. Between 1958 and 1960, these facilities can be combined into a continuous barrier from Midway to the United Kingdom.

An important opportunity to acquire distant information can be exploited in the near future by installing alarm radars at the Joint Canadian – U. S. Weather Stations in the Queen Elizabeth Islands.

GENERAL SURVEILLANCE

In the ocean approaches to North America, friendly naval vessels and merchant ships can provide the basis for a general surveillance radar system that offers high effectiveness at relatively low cost. The system is available today, requiring only the installation of suitable radars and the organization of a reporting net. A similar system might be created by providing radars to inhabited outposts in northern Canada.

REMOTE AIR BATTLE

A long-range interceptor weapon system and its associated radar and air-to-air missiles are technically feasible and can be developed by 1961-1962. The distance from the heartland at which interceptions can be made can be extended from about 700 to over 2000 miles. If employed in remote air battle missions, this weapons system will be an important deterrent to the Soviet striking force.

AIRCRAFT

For earliest operational use, the B-47E can be modified to carry a large antenna and the necessary missiles. For later introduction, the B-58 or PGM-1 can be modified, or a new high-speed long-range interceptor designed.

Summary

DEVELOPMENT PROGRAM

If we start at once to develop suitable weapons, radar and aircraft, we can be ready for the remote air battle if future decisions demand that capability. Meanwhile, we can study the tactics and the alterations required in the rules of engagement.

DEFENSE AGAINST THE SEABORNE THREAT (see chapter 14)

North America is open to attack not only by aircraft but also by ships and submarines. Airborne missiles with nuclear warheads can be launched from the surface of the ocean several hundred miles off our coasts. Our ports can be destroyed by nuclear mines. The air defense system itself can be crippled by seaborne attack on picket ships.

OCEAN SURVEILLANCE

Defense against this threat requires an ocean surveillance system which detects, identifies and tracks all vessels on and below the surface of the sea. We propose the establishment of 600-mile-wide contiguous surveillance zones off our coasts, supported by remote surveillance lines to provide early information. The existence of such a system will be a strong deterrent, even before its technical performance becomes wholly satisfactory.

CENTRALIZED DATA PROCESSING

We visualize the use of digital computers at a Sea Surveillance Center where data from radars, radio direction finders, and underwater sound detectors are correlated with sail plans, ships' reports, and tables of ships' characteristics. The resulting information on position, course, speed, and identity of all vessels is displayed in a summary plot for command purposes.

IMPROVED DATA SOURCES

Such a system will become fully effective only if we continue to improve the available data sources. Experimental work is needed on shore-based ground-wave radar at about 2 Mcps. For improved underwater detection, we need better hydrographic

Summary

data, particularly in northern waters. In addition to improved passive sonic detectors, we need a long-range, low-frequency, active system to meet the threat of the silent submarine.

AIR DEFENSE SYSTEMS AND THEIR EVALUATION (see chapter 15)

MAP EXERCISES

The systems proposals of Project Lamp Light were subjected to evaluation by map exercises and by mathematical procedures. The simplest method of visualizing a system's effectiveness against an attack, and a good method of estimating its quality, is to take the position of an enemy and plan an operation against it, and then study the possible actions of the defense against the attack as it progresses step by step across a map. Two important conclusions emerged from such map exercises:

SAC DEFENSE

Both the ADR 54-60 System and the Lamp Light Modification satisfy the warning and defense needs of the Strategic Air Command. If plans for speedier evacuation, increased readiness, and further dispersal are implemented, the defenses will adequately protect SAC's retaliatory strength.

MASS ATTACK

Against strong air defense systems, a concentrated mass attack is best from the enemy's point of view and is therefore the most important type of attack to consider in air defense evaluation.

MATHEMATICAL EVALUATION

Mathematical procedures were used for an approximate quantitative assessment of the Lamp Light and ADR 54-60 systems. Urban population centers in the United States were assumed to be targets, and calculations were made to estimate the number of enemy bombers that must enter the defense system

Summary

to produce 15 million deaths from bombs on target. This number of hostile aircraft was taken as an index of the effectiveness of the defense system. Separate calculations were made for systems representing different cost levels, for different types of systems, and for different assumptions regarding the use of decoys and anti-air-to-surface missiles.

From the graphs in Chapter 15 which show the results of these calculations, we have drawn the following major conclusions:

(1) Lamp Light Modification

The modified air defense system proposed by Lamp Light for 1960 will provide somewhat better defense, at a comparable cost level, than the system proposed in ADR 54-60.

(2) Decoys

The use of decoys by the enemy could double the effectiveness of his attack against our air defense system.

(3) Anti-ASM Missiles

Conversely, a capability in our air defense systems against the enemy's air-to-surface missiles could double the effectiveness of our air defense system against his attack.

(4) Remote Air Battle

Quantitative comparisons of 1960 air defense systems with remote air battle capability vs systems of equal cost in which all combat resources are concentrated in the contiguous zone, show no great disparity in combat effectiveness between the two types of systems. Qualitative arguments, particularly on the ground of its deterrent value, indicate that a remote air battle capability would improve the air defense of North America.

CHAPTER II
SYSTEMS DESIGN OBJECTIVES

CHAPTER II
SYSTEMS DESIGN OBJECTIVES

NATIONAL DEFENSE CONCEPT

Project Lamp Light has accepted and endorsed the general concept of national defense as enunciated from time to time in various public utterances by the President of the United States, his Secretaries, and the Chiefs of Staff of the United States military departments. This concept, parts of which have been directly stated and other parts of which are deduced from direct statements and from military plans, is summarized in the following paragraphs.

For defense, we shall rely basically and primarily on the deterrent powers of a long-range striking force designed to exploit the power of nuclear weapons, and of a strong tactical air force which also exploits the power of nuclear weapons and is deployed according to plans for a common defense of the entire western world.

These offensive forces will be supported by a third force based in and around North America, in accordance with a joint United States-Canadian plan, designed for defense and comprising primarily:

> Antiaircraft located in proximity to metropolitan areas and other facilities, activities and installations to be defended (gradually changing to self-propelled guided missiles);
>
> Manned and unmanned all-weather fighter-type aircraft;
>
> A system of electronic and other means for observing, collecting and disseminating information regarding plans and operations of any potential enemy.

Project Lamp Light agreed that its study should be limited to the functions and requirements of, and improvements to, the defense force described above. But the Project was constantly mindful of the fact that the offensive forces exist in the interests of, and therefore are integral parts of, the continental defense force. Further, just as the defense of North America is directly related to the defense of the entire western world, conversely, the defense of Western Europe and other foreign areas in which we have interests and responsibilities is a part of the defense of North America.

IMPROVEMENTS IN AIR DEFENSE

The current concept of North American defense is centered around a defensive force based and concentrated in and around the United States (including Alaska) and southeast Canada; it extends outward but less densely into Canada and surrounding ocean areas. In terms of this concept, the improvements recommended by Lamp Light might be described as:

Further extensions and improvements in the means for gathering and disseminating information regarding the activities of the enemy;

Extending the combat area of the defense system into ocean areas and into Canada, with due regard for the interrelations of forces and systems in America and in other theaters;

Increased participation in air defense by the U.S. Navy and the Royal Canadian Navy to accomplish the objectives under the above, together with intensified defense against submarines;

Improvements in component technology, especially in the fields of radar, communications, data processing, identification, and counter-countermeasures.

We should consider it essential to make major changes in the general concept of air defense if it were obvious that correspondingly major improvements would result. Conversely, we should consider it unwise to introduce such changes – with the inevitable confusions, costs and delays that would result – unless the net benefits were to be correspondingly great. In general, the recommendations of Project Lamp Light are for modifications and additions to the defense system as planned, in order to reduce deficiencies that are commonly recognized. To correct these deficiencies, we need:

Tracking and combat capability at low altitude;

Ability to counter an enemy attack using confusion and deception by electronic and other means, and to counter such means as the enemy might use to confuse and deceive us;

Ability to acquire early information regarding enemy positions and actions which is essential to:

Making proper decisions and plans for the operation of our strategic and tactical retaliatory air forces, both in America and in foreign theaters,

Maximizing the availability of all forces regularly assigned to air defense,

Readying all augmentation forces,

Calling to duty full crews within the radar and communications systems, in combat forces assigned, and in the GOC system – all without the necessity of maintaining full crews on a continuous-alert basis;

Combat capability in specific areas: where the enemy might refuel aircraft; through which the basic enemy aircraft might be carrying, for example, decoys, or wing-tip-coupled airplanes – all to give the basic aircraft greater values in remote areas than in areas nearer their objectives; where defensive combat might be more successful, because of, for

example, weather or daylight, than near the enemy's objectives; where mass formations might be greatly reduced and dispersed by weapons that could not be used over populated areas near the enemy's objectives;

Combat capability in time – time that, in the presently planned systems, would be lost while the enemy traverses the greater part of his routes. Utilization of this lost time would:

Allow more deliberate thinking, and greater precision of action, by everyone in the defense system;

Permit fighters to make repeated attacks on aircraft with time to assess the effects of the first action before the second is taken;

Make the planning and execution of the mission much more difficult for the enemy and materially increase the probability of his deciding against such an undertaking. For example, if the enemy were jamming all defense radars throughout his mission, a short period of daylight combat might be of major value to the defense;

Weapons designed to counter the expected threat;

Utilization of naval forces with their potentials for defense, through understandings, plans and interconnecting facilities (mostly communications and data handling).

AIR DEFENSE ROLE OF OTHER FORCES

Studies of the outward extension of our air defense should include consideration of:

A capability in the American Far East air forces to neutralize thoroughly and quickly the elements of the Russian long-range air army and their bases in eastern Siberia;

A capability in the Alaskan Air Command to do the same in other areas in Siberia, east of the 90° meridian;

A capability in the European air forces to do the same in other areas of Russia west of the 90° meridian.

There should be agreements that these are primary missions of these air forces. Such capabilities imply not only that these air forces must be ready to act quickly, but also the use of atomic weapons of high yield, primarily against aircraft on bases and from fast jet bombers.

This field of combat is part of our defense against air attack; it should not be considered as a separate entity from either continental air defense or retaliatory action, and none should be studied independently of the others.

Extension of combat capability similarly covers ocean areas and includes that contributed by the U.S. Navy and the naval forces of other NATO countries. In these forces,

there exists a great potential to engage enemy aircraft threatening North America on both an opportunity and a planned basis.

Project Lamp Light considers it important that this combat capability be made a part of the mission of these naval forces in order to exploit all opportunities to engage and destroy such aircraft. We believe, further, that some relatively small naval forces should be especially deployed and assigned, as a primary mission, a role in the defense of North America against air attack. These small forces include picket ships, possibly some carrier-based air groups off the east coast of the United States, and possibly certain airship groups in the air control and intercept service off the southeast coast of the United States. Endorsing the existing plans to make air defense and antisubmarine warfare corollary missions of certain naval forces, we have recommended strengthening the antisubmarine-warfare effort in the interests of air defense.

THE SOVIET THREAT

In evaluating air defense system designs, it is necessary to establish design objectives or ground rules under which the systems would be examined. Where guides in the form of approved or accepted documents or decisions were available, they were used; however, a great deal of the information required was not available and, where such information was lacking, arbitrary rules were established.

One of the most important factors in defense system design was the threat that the system must be designed to protect against. Based on information contained in the National Intelligence Estimates (NIE), an estimate was formulated (see Appendix 11-A) of the magnitude of the threat and the philosophy of a Soviet attack. The attack patterns assumed for the Soviet were developed by members of the Lamp Light Evaluation Group, and are described in Chapter 15 and Appendix 15-A.

The inclusion of a decoy threat in the 1960 time period was considered to be reasonable and well within the Soviet capabilities from both a technological and economic standpoint. The effect of decoys on the defenses could be so marked that it was felt essential to include them in defense-system evaluation. The performance of Soviet jet bombers was increased over that given in the NIE in an amount considered to be the growth potential of these aircraft during the 1955 to 1960 period.

POSSIBLE COURSES OF THE WAR

The entire philosophy under which the enemy might initiate and wage the war had to be considered, and assumptions had to be drawn from a wide range of

possibilities. There appeared to be four possible situations:

> We shall continue to stalemate the USSR and a nuclear war will not occur.
>
> Nuclear war with the USSR will occur but we shall survive as a nation to win it.
>
> Nuclear war with the USSR will occur and the Soviet will survive to win it.
>
> Nuclear war with the USSR will occur and neither nation will survive, or both will be so badly exhausted that war will end without a victory.

Of the possible situations named above, only the first two could be acceptable to us. This means we must be able to deter a Soviet attack or build a defense system adequate to assure survival under any Soviet attack. Because of difficulty in evaluating the deterrent factors, evaluation of Lamp Light defense systems was based on active defense and not on deterrent capabilities.

If a short war of hours, days or weeks is considered, in which each contestant exhausts his stockpile of nuclear weapons in massive thrusts aimed at a quick decision, then military production capacity and tactical air forces, army forces, and naval forces based in North America, will have little effect on the outcome of the war and on our ability to rebuild after the war. In such a war, atomic energy plants, many military bases, aircraft factories, etc., would have little value and would be lightly defended. If, on the other hand, a war should occur in which each contestant exhausted his nuclear delivery capability without destroying his enemy, a long war could ensue in which army and naval forces and industrial capacity for military production would be vital to the outcome of the war. For evaluating the systems of defense considered by Project Lamp Light, a short-term war was considered, primarily, while other possibilities were kept in mind.

MEASURE OF EFFECTIVENESS

The ability of a nation to survive was considered to be dependent on the survival of people and the industry necessary for their survival. A study conducted by the Joint Air Defense Board indicated that the relative target values are distributed approximately the same if values are based on population, on manufacturing value, or on key facilities.

For the purpose of this evaluation, preservation of the population and the combat air forces was used as the principal measure of defense effectiveness.

LEVEL OF DEFENSE

A difficult item to determine is the level of defense a system should be designed to provide. It may be said qualitatively that the defense must be adequate to give good probability against relatively minor disaster and very high probability against major disasters (millions killed). This latter requirement would suggest the necessity of destroying practically the entire attacking force before it reaches its objectives. However, the probability of the enemy's killing millions of Americans is the product of the probability that he could do it, if he makes the attempt, times the probability that he will make an attempt. If either of these or their product can be reduced to near zero, the defense will be adequate. Fortunately, the reduction in the probability of the enemy's being able to succeed reduces, at the same time, the probability that he will try, and this can be reduced again in other ways; particularly, it can be reduced by maintaining a threat of retaliation sufficient to make an attack on us obviously unprofitable to an enemy.

This does not provide a numerical gauge of an air defense system, but it does provide a good basis for judgment.

It was assumed that the defense level may be limited by the defense budget. Systems design and evaluation were made within a range of values around budget levels assumed by the Continental Air Defense Command for the year 1960.

RULES OF ENGAGEMENT

In extending the air defense battle over international waters, it may be necessary, under conditions of war, to place restrictions on the movements of all vehicles within the defense area if the system is to operate at highest efficiency. Even under peacetime conditions, it may be necessary to consider modifications of our traditional policy of freedom of the seas and the air over the seas. The question thus arises as to what restrictions we must place on traffic in this international air defense zone and what rules of engagement must be established to permit the proper functioning of the defense system in this zone. The difficult period is the one immediately prior to the commencement of war. In view of the tremendous damage a surprise nuclear attack might cause, the defense systems should be so designed to be sure that the necessary restrictions to vehicular movements and the necessary engagement rules could be established. If such restrictions and engagement rules are not provided before war commences, they will necessarily be made as command decisions when they become indispensable. Systems should be evaluated

under widely varying assumptions as to when these decisions might be made. As the combat zone is moved further and further from sovereign territories, the rules of engagement become more and more difficult to establish.

EARLY INFORMATION

An obvious requirement of a defense system is means to obtain adequate advance information. This information must be received in time to make decisions, to call assigned and augmentation forces, to permit the strategic air force to load and depart their bases, to permit commanders time wisely to plan and direct operations, and to permit the entire country to put into effect all possible passive measures of protection. Adequate information regarding the enemy as he progresses along his routes – to permit planning, intercept control and fire control by his commanders – is also essential. Combat capability to accomplish the final kill is another obvious essential, and analyses quickly developed the fact that an adequate depth of combat must be a major criterion on which to base judgment.

APPENDIX TO CHAPTER II

APPENDIX II-A THE SOVIET THREAT

APPENDIX II-A
THE SOVIET THREAT

GENERAL

In establishing a statement of the Soviet threat against the North American continent, the National Intelligence Estimates were used as the main source of information. Information contained in these will not be repeated here. Additional details of Soviet capabilities and tactics not given in the NIE, but which were assumed in evaluation of the defense systems, are set forth below.

THE ATTACK

In considering how the enemy might plan his attack against the North American continent, it was assumed he would do so in a manner that would optimize his chances for success. From this standpoint, there appeared to be two types of attack that were most probable: an all-out attack using all vehicles and weapons available; and a sneak attack aimed at penetrating the defenses without its being identified as hostile, and designed to destroy certain key targets, to be followed by a mass attack a short time later. Although an unlimited variety of other attacks would be possible, their likelihood of success appeared to be less than in either of the two cases named above. It was also assumed that the Soviet would have a nearly complete knowledge of the disposition and capabilities of our defense system elements.

Large Mass Attack

It was assumed that, in briefing the crews for a large mass attack, the Soviet planners would designate a primary target and an alternate target for each bomber. Since it was considered to be impossible to fly a mass raid through our warning systems without giving an almost unequivocal warning, all penetrations of warning lines would be made as nearly simultaneous as possible. While the probability of strategic warning of a mass raid would be high, strategic warning was not considered in the evaluation of any of the defense systems. All northern staging bases of the Soviet long-range air army were assumed to be available for launching aircraft.

Small Surprise Attack

In briefing for the small surprise attack, the Soviet planners would assign only enough vehicles and bombs to attack the targets selected, assuming no defense action. To achieve maximum damage with minimum probability of detection, every effort would

be made to reduce aborts and gross errors by careful preparation and selection of crews and vehicles. Barring discovery of the attack and defense action against it, it was assumed that 90 per cent of the targets selected would be bombed. The size of the minimum raid was determined from the number of targets that needed to be destroyed if the attack were to be successful, coupled with the ability of the defense system to detect and identify such an attack. Surface and subsurface launched missiles were considered an important part of this threat. A small-scale attack would be aimed at simultaneous bomb drop with a random penetration of warning lines.

The Soviets were given the ability to launch aircraft at a rate of one per minute from a given base and to adjust launching time, speed and course so that any bomber could arrive over a check point within or near the United States with an error of ±10 minutes. It was assumed that all attacks against the United States and Canada would be on one-way missions in order to provide maximum altitude over target and sufficient range to reach all targets, to allow for variations in wind velocities, and to permit time for forming into mass attacks. Maximum ranges were computed with one hour of fuel remaining and for carrying a 10,000-pound pay load. It was also assumed that all TU-4, Type 37 and Type 39 aircraft would be available for strikes against the United States and Canada, and that simultaneous attacks would be carried out on European, African, Alaskan and other areas by short-range aircraft of the IL-28 type. Delivery of bombs by clandestine methods and sabotage, while possible, were not considered, because of the difficulty of evaluating such a threat.

VEHICLES

The quantity and types of vehicles considered in the threat and performance of Soviet aircraft for the 1957-58 period were based on data available in the NIE. However, for the 1960 time period, the performance of the Type 37 and Type 39 aircraft was modified as shown in Fig. 11A-1. This increase in performance was considered as normal growth potential for these aircraft and was based on the performance characteristics of a modified B-47 having greater wing area and J-57 engines, and of the B-52C.

In addition to the vehicles listed in the NIE, a decoy threat was considered within the capabilities of the Soviet for the 1960 period. Two types of decoys were considered: a short-range decoy of about 100-mile range and a long-range decoy of a 1000-mile range. These decoys would have a speed, altitude and radar reflecting area approximating those of a jet bomber. In using decoys, it was assumed that a bomber could

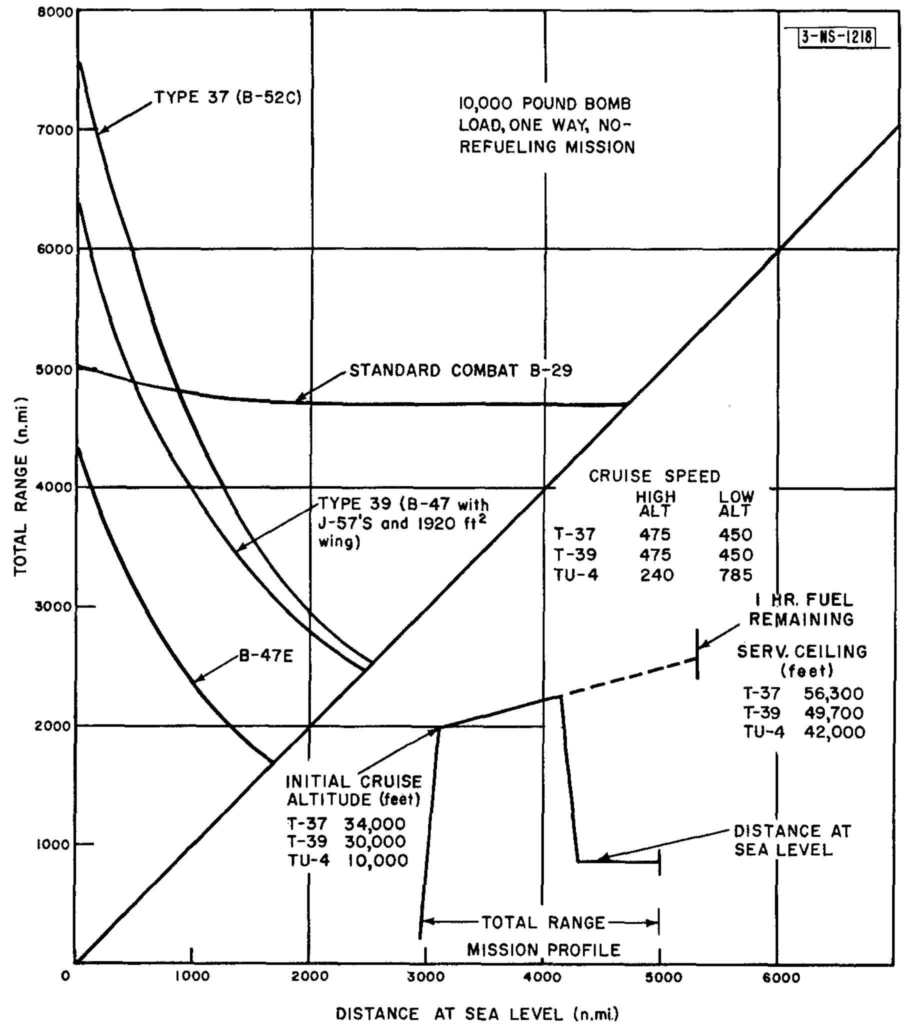

Fig. 11A-1. Estimated Soviet bomber performance – 1960.

carry three 1000-mile decoys or nine 100-mile decoys. The type and quantity of decoys would depend upon the Soviet evaluation of the defense system against which they would be used.

In design, the decoys would be as simple as possible consistent with their function. An inertial guidance system with an accuracy of ±5 miles for each 15 minutes of flight time was considered adequate. Low-altitude flights would be made with the use of a radio terrain-clearance instrument. One or two programmed turns and one altitude change were allowed in the long-range decoy. No changes in course or altitude were included for the short-range decoys.

From weight and size considerations and the technology and time required for production, it was considered feasible for the Soviet to have by 1960 an air-to-surface missile of about 100-mile range, rocket-propelled at a speed between Mach 2 and Mach 3. This missile would carry a warhead of several megatons yield, weigh between 12,000 and 15,000 pounds, and could be carried in the bomb bay of either the Type 37 or Type 39 bomber. It would be guided by inertial guidance after launching, with a CEP of 2 miles plus launching errors. For determining the effectiveness of the surface-to-air missile systems, it was estimated that this missile would have a radar reflection area of 0.5 m^2.

NUCLEAR WEAPONS

In examining the destruction to be expected from a Soviet bombing, it was apparent that the number of bombs available was greater than the number required substantially to destroy the country. It was also apparent that, to deliver these bombs, the attack aircraft must overpower the defenses. The mathematical analysis of this, as given in Chapter 15, indicates that the best utilization of bombers would be to assign a portion to carry decoys and the rest to carry bombs. Since the number of megaton bombs available would be greater than the number required, it was assumed that the Soviets would take advantage of the bonus of fall-out, and the lessened requirement for bombing accuracy inherent in the use of megaton bombs, and carry only these.

SURFACE AND SUBSURFACE ATTACK

While there is no direct intelligence indicating that the Soviet is planning to modify surface and subsurface vessels for atomic attack against the North American continent, the technology and the ability to do so was granted them. From weight and size considerations, the Soviets were given a capability of launching subsonic pulsejet or turbojet missiles of as great as 500-nautical mile range at speeds about Mach 0.8 in the 1960 period. Rocket-propelled ballistic missiles with a range between 80 and 100 miles could also be available in this time period. The use of the above-named missiles was on an either-or basis, and it was not expected that the Soviets would provide for both missiles.

Because of the long transit time required for surface and subsurface vessels to reach their objectives, coupled with the greater probability of their being discovered and identified before they could complete their mission, it was assumed that this method of attack would be limited to approximately 6 vessels in the Atlantic Ocean and 4 in the Pacific Ocean in any initial surprise attack.

COUNTERMEASURES

The countermeasures listed below are an estimate of what the Soviets could have available in the time period under consideration. No attempt was made to estimate the extent to which the Soviet would employ countermeasures; however, the great reliance placed on electronics in our defense system should make it very profitable for the Soviets to invest a considerable effort in electronic countermeasures. The tremendous increase in bomb yields, which has greatly reduced the number of bomb carriers required, should allow release of a large number of bombers (or aircraft manufacturing facilities) for the purpose of assisting the bomb carriers through our defense system.

Electronic Jamming

In the 1957-1958 period, the Soviets could have an electronic jamming capability for spot, barrage, and sweep jamming which will be limited only by the carrier capacity the enemy may wish to commit to this mission. The reduction in aircraft range imposed by the use of electronic jammers for this period would be one pound of fuel per watt per megacycle of bandwidth jammed. In 1960, through the introduction of new techniques and components (such as the Carcinotron, see Appendix 4-A), the weight penalty will be reduced to approximately one-quarter pound per watt per megacycle. By 1960, the Soviet could have a broadband repeater capability.

Chaff

From 1957 on, the use of chaff by the Soviet would be limited only by the employment selected. Sufficient chaff could be available for sowing chaff corridors or for other tactics against ground radars and for use against fire-control systems both ground and air. Four hundred pounds of chaff and chaff-dispensing equipment would provide adequate quantities for use against interceptors and ground fire-control systems. For area sowing of chaff, one-half pound per cubic mile was considered adequate for protection against ground search radars. Forward-projected chaff could be available as early as 1957 at an increased weight factor of from five to ten times that of dispensing into the slipstream.

Airborne Targets

Airborne targets such as Toastmaster could be available in unlimited quantities by 1957-1958 period. In this period, however, they would be sown by relatively slow-moving cargo aircraft which would be highly vulnerable to attack unless the sower

remained outside weapon range. Considerable time would be required for the targets to drift into defense areas, which might provide advance information on the attack, which in turn would tend to negate their value. By 1960, these targets could be laid by high-speed, high-altitude jet aircraft. For complete area confusion, one target per cubic mile would be required.

Homing Missiles

By 1960, the Soviet could have in being a homing missile designed to home on the air defense radars. These missiles could be jet-powered at near-sonic speeds with a range in excess of the control range of the AC&W radar. They could be equipped with low-yield atomic warheads. The decision by the Soviets to use such missiles would be based on the expected effectiveness as compared to electronic countermeasures, decoys, etc.

D. W. Patterson

CHAPTER 12

THE CONTIGUOUS AIR DEFENSE ZONE

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I. INTRODUCTION

Among the main problems studied by Project Lamp Light were the feasibility of obtaining a more distant, or remote, air battle, and the compatibility of the continental defense system with naval forces that might be used in extending the air battle seaward, together with the related problem of data handling. It is clear that these problems are not separate, but are deeply interrelated. It was recognized that continental defense is an extremely complex problem and that attempts to find solutions should be examined in terms of their employment in an over-all defense system. For example, after studying the outward extension of continental defense to produce a more remote air battle, it is possible to examine the employment of naval forces in this outward extension and the means for providing data-handling systems that will make these forces effective. The objectives of the systems studies are therefore summarized as follows:

To explore the possibilities of achieving a more effective continental defense than present plans will provide for the 1960 period.

To explore the technical feasibility of a more remote air battle than that envisaged in present plans.

To study the possible roles of the Navy in continental defense.

To provide specific, integrated continental defense systems for evaluation of new techniques and concepts considered by component groups.

To reveal the policy problems and rules of engagement that are required to effectively employ the weapons systems considered.

To provide defense models for examining the effects of strategy, tactics, and countermeasures on the weapons system and its components.

Early in the Lamp Light project, two groups were organized to conduct independent studies of complete defense systems. These two groups considered many possible approaches to the problem of the outward extension of our defenses, rejecting those that proved unsound and carrying the better ideas over into the next configuration. After a number of weeks of independent study by the two groups, it became apparent that the systems taking shape in both groups had many things in common, and that the groups' concepts and conclusions were similar in many respects. At this juncture, a decision was made to combine the efforts of the two systems groups in order to bring forth the best ideas from both and to prepare a single over-all system, with variations, to be used for the purposes listed above.

These efforts produced the design of a complete continental defense system for 1960 which realistically faces the total threat and which illustrates a technically feasible, integrated defense system as a solution to the problems assigned to Lamp Light. The system is described by three chapters of the report. This chapter presents chiefly the characteristics of the inner and contiguous defense zone. Chapter 13 decribes information gathering, general surveillance, and the remote air defense zone. This more remote combat zone may be added to the contiguous zone if desired. Chapter 14 covers the parts of the system dealing with the seaborne threat. Before detailing the features of the contiguous zone, some additional points must be made about the threat, as well as the assumptions and philosophy that motivated the configuration of the entire system.

II. THE THREAT

Detailed examination of the threat, as set forth in Appendix 11-A and related documents, revealed the following important points pertinent to configuration of the contiguous system for 1960.

Comprehensive continental defense systems must guard against the air threat, the surface threat, and the subsurface threat. A defense system that defends against one or two of these to the exclusion of the rest is unrealistic and incomplete. System configuration, therefore, should give some attention to countering the threat of the enemy submarine and the submarine-launched missile as well as missiles launched by surface ships.

The all-out massive air attack, however, is by far the most dangerous threat and the most difficult to stop. Enemy ability to mount such a raid, and to concentrate it in time and space for purposes of achieving maximum saturation of a narrow sector of our defenses, is assumed.

The 1960 airborne threat extends from the surface to at least 50,000 to 60,000 feet and possibly higher. Even though the Soviet long-range air force were converted largely to jet bombers by that year, it is believed that the low-altitude threat will still exist. A substantial low-altitude run-in distance to our target areas is possible for one-way missions, and this can be considerably extended by development of in-flight refueling capability. Therefore, the low-altitude target does not disappear with the obsolesence of the piston-powered TU-4 bomber.

There is a definite possibility of enemy use of air-to-surface missiles of approximately 100-mile range for terminal delivery of bombs.

There is a definite possibility of enemy use of air-launched decoys flying at bomber speed and simulating bomber-target characteristics. Extensive use of such decoys could increase the number of enemy flying objects within a given defense area by factors of three to six or more.

Massive use of electronic countermeasures for radio and radar jamming is a definite technical possibility and, if used by the enemy, could seriously impair presently planned defenses.

III. APPROACH, ASSUMPTIONS AND PHILOSOPHY

The Lamp Light systems studies were started by first reviewing the present defense plans for the next five years, as prepared by the Air Defense Command. This was done through numerous briefings given by personnel from the appropriate military commands, and by close study of the Air Defense Command's 1954-1960 Plan* (hereafter referred to as ADR 54-60). This was found to be a very comprehensive plan; if implemented, it will provide a substantial increase in our continental defenses by 1960.

Since this plan will be frequently referred to in our report, a brief summary of the main features of the plan appears to be in order.

The ADR 54-60 plan (Fig. 12-1) seeks to give the strongest defense to about 165 urban area targets and 21 isolated critical targets. The urban area targets are such as to permit grouping into geographical target complexes in the northeastern, northwestern, and Californian areas as shown. Early information is provided by a land-based Distant Early Warning (DEW) radar and Fluttar line in Alaska, Northern Canada and Labrador, a mid-Canada radar and/or Fluttar line, an Atlantic Airborne Early Warning (AEW) sea wing from Newfoundland to the Azores, and a Pacific AEW sea wing from Hawaii to Alaska. A total of 80 AEW aircraft (20 continuously airborne) and 10 picket ship stations are used for these sea wings.

The weapon systems employed in the combat zone include long-range interceptors, medium-long-range interceptors, medium-range interceptors, and long- and short-range missiles. The principal characteristics and numbers used are summarized in Table 12-I.

These weapons are deployed in such a manner as to give the heaviest protection to the northeast heartland area. Approximately 70 per cent of the weapons are deployed in and around this area. The air battle is conducted in a combat zone as indicated in Fig. 12-1 which extends outward to the north and east of the heartland about 475 miles, and about 250 miles into the Pacific and the Gulf. The air-surveillance and weapon-control functions are provided by long-range land-based radars and gap fillers, CW

*Air Defense Requirements, 1954-1960 (ADR 54-60), 1 July 1954.

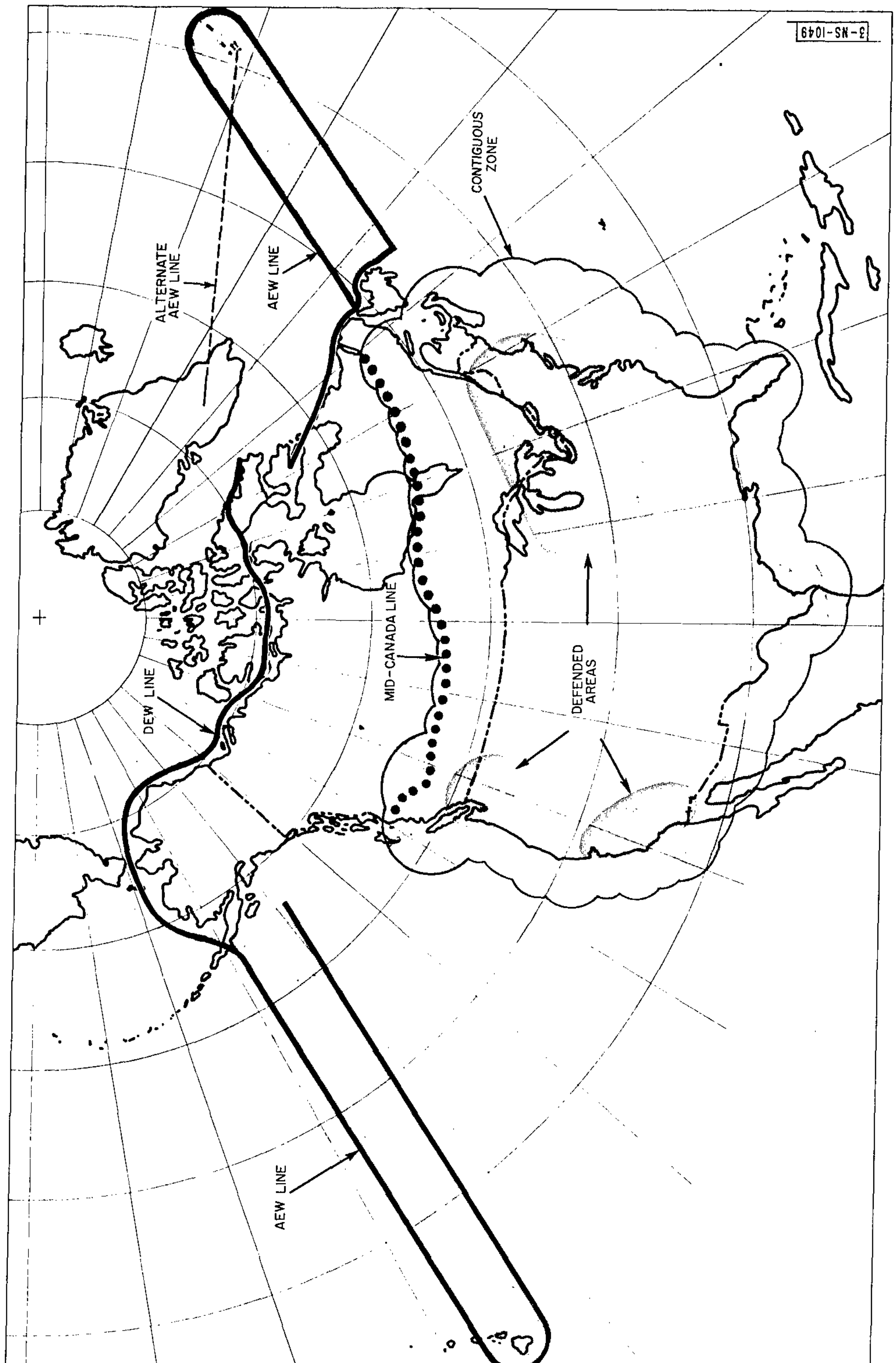


Fig. 12-1. ADR 54-60 air defense plan, 1960.

TABLE 12-I ADR 54-60 PLAN WEAPONS				
	Approx. Combat Radius (n.mi.)	Approx. Maximum Speed	Armament	Number of Squadrons or Battalions
Long-Range Interceptors	1000	M 2	Ding-Dong, Falcon, Rockets	29
Medium-Long-Range Interceptors (F-101)	840	M 2	Ding-Dong, Falcon, Rockets	9
Medium-Range Interceptors (F-102)	350	M 2	Ding-Dong, Falcon, Rockets	75
Long-Range Missiles (F-99 or L-253)	150	M 2.7	Atomic or HE warhead	53
Short-Range Missiles (Nike B or Talos)	50	M 2.3	Atomic or HE warhead	100

radios, Texas Towers, picket vessels, AEW&C aircraft, and a series of direction centers and combat centers of the SAGE (Semiautomatic Ground Environment) System. A recapitulation of the approximate numbers of these units follow:

Direction Centers	40
Combat Centers	9
Long-Range Radar Stations	212
Gap-Filler Radars	423
CW radios (Fluttar)	159
Picket Vessel Stations	4
Texas Towers	5
AEW&C Aircraft	126

The estimated cumulative capital cost of the system is about 21.4 billion dollars for the period FY 1955-1960 inclusive. The cumulative operating cost for the same period is about 20.7 billion dollars. The estimated annual operating cost for the year 1960 and beyond is approximately 6.3 billion dollars.

Study of the ADR 54-60 plan revealed a number of possible disadvantages and weaknesses which should be improved for the 1960 period. These areas for improvement, undoubtedly well known to the Continental Air Defense Command, (CONAD), may be listed in summary as follows:

Low-altitude air defense still appears inadequate. The extent of the low-altitude coverage is too small and in some cases the coverage is too sparse. The low-altitude detection capability of the AEW aircraft in the presence of clutter is inadequate and must be substantially improved. The same is true for the detection and lock-on ranges of the AI radars for the interceptors. The capabilities of both the air-to-air missiles and surface-to-air missiles at low altitude are limited.

There is considerable dependence on centralized control of the air battle, particularly to seaward, with limited back-up in case of failure of these centralized controls.

The data zone seems inadequate for the efficient utilization of the interceptors and weapons available by 1960. We believe, for example, that the 1000-mile-radius long-range interceptor specified by this plan would be inefficiently used for loiter at the edge of the contiguous cover (475 n. mi.) since it will not possess an AI radar with anything approaching the performance specified (100 miles on a 1-m^2 target). Furthermore, it appears doubtful that the airplane itself would be available in operational quantities by 1960. We believe that combats at even greater distances can be performed by much smaller and less costly interceptors provided a wider data zone can be obtained.

Mass attack by very large compact raids would tend to saturate the fairly narrow combat zone of 475 miles called for in this plan.

The defense is vulnerable to countermeasures and decoys. Massive use of electronic countermeasures can reduce the detection range of radars by a factor of 10 or more. Similarly, extensive use of decoys as mentioned earlier could increase by a large factor the number of flying objects the defense would have to track, identify and attack.

It appears that there is inadequate early warning on raids coming in toward the heartland through the early-information barrier in Labrador and Nova Scotia.

Only limited protection from the south and west is provided. High-altitude radar coverage in the Gulf area extends out only 250 miles. The one-way non-refueled range of the TU-4 would permit penetration of our combat zone from these directions. While it is not likely that this route would be used for very large raids to attack our vital targets of population and industry, it might be used in sneak attacks against the Strategic Air Command.

The next step in the Systems Group studies was to make certain assumptions and agreements defining objectives and setting up requirements that the systems must meet.

One of these assumptions concerned a decision as to what we are trying to defend. Obviously, we should like to defend the entire North American continent and everything in it as well as our friends overseas. This appeared to be a monumental task, perhaps completely outside our technical capabilities and the size of our pocketbooks. The question was then asked: if we cannot defend the entire continent, what part do we

want to save in the event of an all-out nuclear attack? A study of population distribution in Canada and the United States indicated that, of a total of 70 units (1,000,000 people per unit) which are located in cities of 100,000 population and greater, 47 units are located in the northeast heartland area. The result of considerations such as these led to the conclusion, very similar to that of ADR 54-60, that we should make every attempt first to give an adequate defense to the northeast United States - southeast Canada heartland, plus certain key facilities, industrial areas and retaliatory forces as indicated in Fig. 12-2.

It was further agreed that the protection of our retaliatory forces should include dispersal of bases, adequate early warning to allow evacuation, and necessary defenses to prevent a sneak attack from destroying these forces. As a result of briefings given to Project Lamp Light by representatives of the Department of Defense, it was assumed that the time required in 1960 to evacuate aircraft (and sortie some toward the USSR) from a SAC base would be a maximum of approximately 2-1/2 hours in addition to decision time. If decision time is arbitararily taken to be half an hour, essentially all the flyable aircraft on a given SAC base could be evacuated in approximately three hours. This was taken therefore, as representative of the kind of time required to give SAC adequate early warning.

It was agreed that a "no soft spot" philosophy would be followed. The complete, integrated system would defend against the air, surface and subsurface threat so that the enemy could not find an "Achilles Heel."

A time period for the study had to be selected in order to be specific for purposes of evaluation and comparison with present plans. It seemed reasonable to use the ADR 54-60 plan as a baseline for comparing effectiveness of any alternative systems. 1960 was therefore selected as a date for comparison of these two systems.

The philosophy used in designing the contiguous system was to start at the target areas and build defenses outward within the limits of our technical, production and budgetary capabilities by 1960. This approach permitted a smooth transition between now and 1960, making maximum use of existing weapons, equipment and vehicles. A special effort was made to achieve maximum compatibility with current CONAD plans, consistent with the aims and purposes of the system. However, to improve the ADR 54-60 plan, it was evident that a substantially wider data, or surveillance, zone around the defended areas is needed to employ more effectively the interceptors that will be operationally available by 1960. When this is properly done, a substantially deeper combat zone will also be obtained. The design of this deeper zone can be directed toward the following objectives:

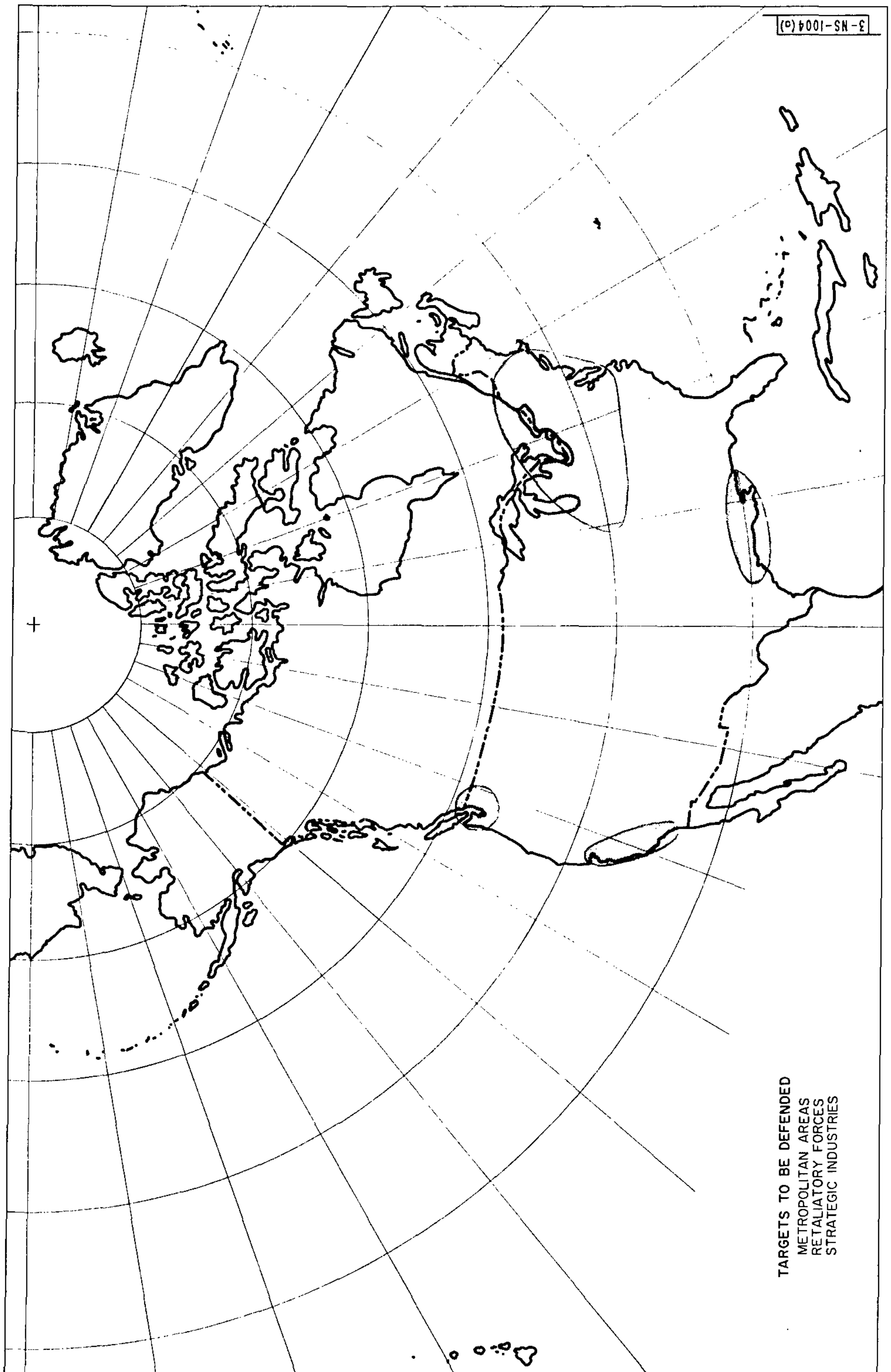


Fig. 12-2. Targets to be defended.

To make difficult the use of saturation and breakthrough tactics by compact mass raids of enemy bombers striking a narrow sector of a defense system.

To positively establish identification and enemy intentions at the greatest possible distance from the heartland.

To increase substantially our capability to detect and kill low-altitude raids.

To provide more time to break up large compact formations by continuous attack.

To attack bombers before launching of short-range air-to-surface missiles and decoys.

To subject enemy crews continuously to harrassment and attack for long periods during approach to the defended areas.

To confront the enemy with a multiplicity of vehicles and detection devices, such as radars (different frequencies, powers and locations on the surface and in aircraft), infrared equipments, and radio direction finders. This is to complicate his use of countermeasures.

To provide greater flexibility and mobility to the defense for the purpose of meeting the greatest possible variety of attacks and enemy capabilities and to complicate, substantially, enemy planning of strategic air attacks against the continental United States and Canada.

To give defense commanders more time in which to make assessments and vital commitment decisions.

To prevent damaged enemy bombers from surviving long enough to reach their targets.

BASIC SYSTEM DESIGN:- For first design of the system, a level of defense expenditure had to be selected. It was decided first to design a modification of the ADR 54-60 plan at about the same budget level so that the relative effectiveness of the two systems might be compared directly on the basis of the amount of continental defense that they provide. For brevity, this first modification of the ADR 54-60 plan will hereafter be called the Basic Lamp Light System. Its design is discussed in Sec. VI.

Several variations from this Basic Lamp Light System were considered desirable in order to provide study and analysis of certain other factors.

SCALED-UP AND SCALED-DOWN VARIATIONS:- The most important variation is the scaling up and down of the defense level. It was felt desirable to determine the effectiveness of the basic system at a budget level somewhat in excess of the ADR 54-60 level, and also below this level, for the purpose of obtaining a curve of effectiveness vs cost. It was decided that this should be done by increasing and decreasing the basic system budget by about 15 per cent. These variations are discussed in detail in Sec. VII.

PERIMETER MISSILE VARIATION:– A variation in the type of close-in heartland defenses was decided upon in order to investigate the relative advantages of Nike-type missiles supported by all the interceptor squadrons that the budget could afford, as compared to a Talos perimeter area defense provided at the expense of some interceptor squadrons. This variation is discussed in Sec. VII.

MINUS EARLY-INFORMATION VARIATION:– The basic system was designed to provide substantially all the warning required for SAC starting from the edge of the contiguous cover. However, there are some qualitative reasons why additional non-contiguous early information may be desirable and necessary, and the design of the basic system includes facilities for such early information. In order to provide a basis for evaluating non-contiguous early information strictly on the basis of its contribution to combat effectiveness the combination AEW and DEW line stretching from Midway to the United Kingdom, which provides the non-contiguous early information, was removed from the basic system. This variation is described in Sec. VII.

1957 VARIATION:– Since one of the objectives of the systems group was to achieve maximum compatibility with present plans, the desirability of a smooth transition in moving towards the 1960 position was recognized. It was decided, therefore, to examine the defense system at an intermediate point, which was taken to be 1957.

The defense posture in this period is discussed in Sec. VII.

IV. WEAPONS

Prior to discussing the configuration of the Basic Lamp Light System, the characteristics of the weapons and surveillance and weapons control will be described.

The weapons used in the contiguous battle zone are those for which procurement or development testing are well under way. These weapons can be available in operational strength by the time periods considered. For the system described for 1957, the weapon types and numbers are identical with those specified in ADR 54-60. For the 1960 time period, the weapon types are those used for the ADR 54-60 plan with the exception that the 29 squadrons of long-range Interceptors* and the 53 squadrons of Bomarc missiles have not been used. It is believed by Lamp Light that the above-mentioned weapons will not be available in sufficient operational quantities by 1960 to be combat-effective. In order to compensate for the lack of long-range interceptors and Bomarc missiles in 1960, the numbers of medium-long-range

*USAF Military Characteristics MC No.368 (AD-3-A1), 26 April 1954.

and medium-range interceptors as well as the local surface-to-air missiles have been increased above the ADR 54-60 plan. When and if the long-range interceptor and Bomarc missile become available, it appears that the over-all system posture described herein would not be seriously affected.

Interceptors

To facilitate the defense system description, the characteristics of specific weapon types have been used. It is also believed prudent to assume that only USAF air defense and RCAF air defense interceptors could be counted upon for use in an initial all-out air attack against the North American continent. Consequently, only the characteristics of air defense interceptors will be discussed. Appendix 12-A gives the detailed interceptor performance and presents the interceptor system probabilities that were estimated. It should be clearly understood that the system operation probability estimates are predicated on fairly close ground- or sea-intercept control and on the use of much improved airborne-intercept radar for low-altitude attacks in the 1960 time period. Further, the use of high-kill-probability armament is necessary, such as atomic warhead rockets (Ding Dong). Table 12-II summarizes the main interceptor characteristics and the expected kills per interceptor committed to an air attack. The interceptor characteristics are taken from the best available information sources and imply a reasonable growth in aircraft performance and armament complement by 1960. The AI radar types and characteristics specified in Chapter 3 are also required. The expected kills have been averaged over a wide range of battle conditions.

The 1957 interceptor capabilities are also shown in Appendix 12-A.

Surface-to-Air Missiles

The surface-to-air missiles used in Lamp Light systems are versions of Nike and Talos. They are discussed briefly in the following paragraphs. More complete information is presented in Appendix 12-A.

Nike 1 is the only missile available for 1957. This missile uses command guidance and has an HE warhead. Its maximum range is 25 n.mi. The system average kill probability was estimated to be 0.3 per round. A battalion of Nike 1 consists of 4 batteries, each capable of controlling one missile at a time.

Nike B could be available in desired quantities by 1960. It has a maximum range of 50 n.mi., and an HE warhead. In addition to the command guidance presently planned, an active seeker and suitable proximity fuzing must be incorporated to provide a low-altitude capability. The system average kill probability was taken as 0.5 per round.

TABLE 12-II

1960 INTERCEPTORS

Type	Effective Combat Radius (n.mi.)*	Max. Speed at 35,000 ft	Armament	Fire-Control Radar	Expected Kills**	
					High Alt.	Low Alt.
Medium-Range Interceptor (F-102B)	300	M 2.0	3 Ding-Dong rockets or 6 air-to-air missiles	Spaced-active CW (3 antennas) or pulse-Doppler	1.43	0.7
Medium-Long-Range Interceptor (F-101B)	700	M 2.0	3 Ding-Dong rockets plus 2.00 in rockets or 6 air-to-air missiles	S-band with a 40-inch diameter antenna	1.76	1.12
Medium-Range Canadian Interceptors (CF-105)	460	M 2.0	3 Sparrow III air-to-air missiles	Spaced-active CW (3 antennas) or pulse-Doppler	0.97	0.47

*The effective combat radius is defined as 85 per cent of the MIL-C-5011a Area Intercept Mission Radius to allow for more combat time or combat at low altitudes and high power

**Against jet bomber targets with the primary armament complement shown (ex: 3 Ding-Dong rockets for the medium-range interceptor)

Nike B* has the same range as Nike B, but has a low-yield atomic warhead which raises the system kill probability to 0.72. It, too, is assumed to have a seeker and proximity fuze. The 1960 Nike battalion is composed of three batteries of Nike B and one battery of Nike B*, each battery having 56 missiles and dual guidance so that it can control two missiles simultaneously.

Talos L, an advanced-performance version of the present Talos missile, can also be available in desired quantities by 1960. Its range is 80 n.mi. It has an HE warhead, with a system kill probability of 0.5 per round. It employs the beam-riding-plus-homing of the present version, except that a change-over to CW in the homing system is necessary in order to provide low-altitude capability.

Talos LW is the atomic-warhead version of Talos L, and has the same range. Its guidance is beam riding without homing. The system kill probability is taken as 0.72.

A Talos battalion will consist of four batteries, each having 30 Talos L missiles and 30 Talos LW missiles. A battery was assumed to have dual multiplex guidance, that is, it could have missiles homing on two different targets and keep additional missiles in the air simultaneously.

The Nike weapons were considered for land use only. The Talos weapons were considered to be suitable for launching from land sites and from missile ships.

Augmentation Forces

As mentioned previously, the only fighters used for purposes of numerical evaluation against an initial all-out air attack are the USAF and RCAF air defense interceptors. However, a substantial number of augmentation fighters are based in North America. Although the quantity and availability of these aircraft vary greatly from time to time, these augmentation forces would be a valuable addition in the event of a prolonged attack or strategic warning on the order of 6 to 24 hours. The ADR 54-60 plan states that approximately 109 squadrons of SAC, TAC and ATRC supersonic fighters would be based in the United States in 1960. In addition, about 12 squadrons of RCAF augmentation aircraft would be available as well as 24 squadrons of naval supersonic fighters. The 9 squadrons of NEAC and ALAC interceptors were also considered as augmentation forces.

Based upon the Navy's capabilities for defense, it would appear desirable for the Navy to allocate some given number of the fighters in the shore-based squadrons for use against an initial minimum-warning attack. The aircraft would be on a constant air defense alert status and under the control of the area air defense commander as is the

current practice during air defense exercises. This number of aircraft would necessarily be small in view of other Navy commitments, but would be a valuable addition to continental air defense. It is recommended that a firm program along the above lines be instituted if at all possible.

V. AIR SURVEILLANCE AND WEAPONS CONTROL

The components and some of the procedures necessary for air surveillance and weapon control in 1960 have been described in earlier chapters of this report. It is the purpose of this section to indicate how these items are combined for air defense systems. The "building blocks" are described here, and Sec. VI discusses the specific quantities and locations for the basic system. For convenience,the air surveillance and weapon control are given for each of three categories: ground-based, waterborne and airborne.

Ground-Based Air Surveillance and Weapons Control

The air surveillance over land, which includes both detecting and tracking of enemy and friendly aircraft, is achieved by ground-based radars which have been discussed in Chapter 4. Long-range radars and gap fillers are used to obtain the position of flying objects. The long-range radars, such as the FPS-3/GPA-27, have a detection range on a non-jamming 2-m^2 target of approximately 180 to 200 miles from about 25,000 to 65,000 feet. The range below 25,000 feet is limited by the radar line-of-sight. In order to have overlapping radar coverage by 2 (or even 3 long-range radars in critical areas), to take care of breakdowns, time off the air for routine maintenance, etc., the long-range radars are spaced about 150 miles apart.

The advantages of using more than one frequency at each radar to improve the resistance of the system to enemy countermeasures have been discussed in considerable detail in Chapters 4 and 9.

The long-range radars can be located to provide high-altitude coverage over practically all the United States and southern Canada and extending out to sea about 200 miles. Texas Towers do not conveniently fit in any of the three categories previously given. It is planned to locate 5 Texas Towers in shallow water about 100 miles off the Atlantic coast in the vicinity of New York and Boston. These "land-based radars" will extend the coverage to the seaward about an additional 100 miles.

In regions where it is desirable to have air surveillance at all flight altitudes, it is necessary to locate gap-filler radars between the long-range radars. The gap fillers "plug" the low-altitude hole that exists between the long-range radars due to the earth's

curvature and the line-of-sight characteristics of high-frequency radar. The spacing between the gap fillers varies from about 50 to 80 miles, depending upon the local terrain and how "solid" the low-altitude coverage (500 feet) must be. Since it is feasible to dead-reckon tracks for a short time, small low-altitude holes can be tolerated.

Gap fillers, such as the FPS-14, which have a detection range on a 1-m^2 target of about 30 miles and up to about 6000 feet altitude, can be effectively used. One of the design objectives for a gap filler is that it shall be capable of unattended operation and be serviced by roving maintenance teams. Data from the gap filler are relayed to a nearby long-range radar.

Complete detection and tracking data must provide the altitude information, as well as the plan position, on all aircraft. The several ways of doing height finding have been discussed in Chapter 4. Since height-finding radars are located only at the long-range radar sites, the altitude of all aircraft can be determined except those that fly at low altitudes. For the low-altitude aircraft, their altitude can be determined by inference when they are detected only by a gap-filler radar and not by a long-range radar.

After the air-surveillance system has detected flying objects, they must be identified to separate the enemy and the friendlies. It has been proposed in Chapter 8 to equip all military aircraft with secure electronic identification. When this is available, military planes can be readily identified at any time and at any place within the surveillance system.

Non-military traffic which originates inside the surveillance system could be continuously tracked from take-off to landing. If facilities do not permit tracking all flights, certain exemptions must be made, such as aircraft flying at speeds below 150 knots.

Identification of non-military aircraft that enter the surveillance system should be by a code word and possibly an aircraft maneuver (such as a specified turn) in conjunction with electronic aids for communication and navigation. Navigational facilities must be maintained to permit the pilot to know his position to within about 10 miles when within 150 miles of the detecting radar.

One of the functions of the air-surveillance system is to provide detection and tracking data for the weapons system. By 1960, a highly automatic data-processing system will have replaced the present manual system. The SAGE System will be used where traffic density is high and where sufficient land-line communications are available; where this is not the case, such as in Canada above the 50th parallel (approximately), the proposed Cadar system can be used (see Chapter 7).

In the United States (and possibly southeastern and southwestern Canada), the country will be divided into subsectors approximately 150 by 250 miles. Within each SAGE subsector there will be 4 to 6 long-range radars and 8 to 12 gap fillers. It is planned to locate special-purpose computers at each long-range radar site to convert the radar data into coordinates which are transmitted via land lines to the computer at a data-processing center. The computer keeps track of all the targets within its subsector, has stored flight-plan information for identification purposes, and calculates the intercept vectors. The computer automatically relays the vectors to the interceptor via discrete address data links. The capacity at any one time of each of the SAGE computers is 400 tracks, so that 200 interceptions can be carried on simultaneously. There will also be a standby computer for reserve and maintenance in each subsector.

The SAGE System is expected to work with both interceptors and future missiles of the Bomarc type. Also, the SAGE computer can supply acquisition data or general information to Nike and Talos battalions which have their own acquisition and tracking radar.

The Cadar system is a semiautomatic data-handling and display system which can be used in areas where traffic density is light or where sufficient land-line communications have not been established and where their establishment would be difficult. Installed in areas contiguous to regions covered by SAGE, the Cadar system is designed to provide local close control of interceptors. Each Cadar computer at a prime radar could track approximately 1000 targets. Interception capacity is not yet settled. If it is desired to increase the capacity, other computers can be added in parallel.

As noted earlier, the SAGE System requires extensive land-line communications to link the radars with the computer. The weapon-control commands from the SAGE computer are relayed over UHF channels. The Cadar system, which minimizes communication requirements (because of decentralization), also uses UHF channels for weapon control.

Waterborne Air Surveillance and Weapon Control

For part of the seaward extension of contiguous radar coverage, the Navy has planned to use YAGR-type ships. (Alternative possibilities for sea stations are discussed in Appendix 12-H.) These ships are a means of locating radars in the ocean areas. A stacked-beam search and height-finding radar, such as the SPS-2, on these ships corresponds to the long-range radar sites on land and has about the same detection ranges as the land-based radars. It is proposed in Chapter 4 that the picket ships be equipped with two air-search radars, one of which would be a stacked-beam search and height-finding radar. In addition, there would also be a separate nodding-beam height finder.

With detection ranges of the shipborne radars of the order of 180 to 200 miles, picket ships can be spaced approximately 300 miles on center to provide solid high-altitude coverage. The ships can position themselves with an accuracy of approximately ± 1.25 n.mi. under good conditions. At the present time, there are no known techniques to use waterborne radars to obtain solid low-altitude coverage in the same manner as for the gap fillers used on land. The use of airborne radars will provide radar coverage from sea level to 60,000 to 65,000 feet which will plug the low-altitude holes. Thus, there is a redundancy or overlap in the high-altitude coverage from the radars on the picket ship and aircraft.

As was discussed above, extensive land-line communications are required to tie the long-range radars into the SAGE computer. Since there are no land lines between the picket ships and shore, the radio communication requirement to relay all data to a shore-based computer becomes prohibitive. Furthermore, in the interests of decentralization, it is desirable to have a naval data-processing system, as in the Phase 2 proposal of Chapter 7, on board each of the picket ships. By having an intercept computer on board each picket ship, the communication requirements are minimized. Each ship can operate individually or as a unit in a group. High data-storage capacity on each ship stores all tracks and other data of interest within a prescribed operational area. The central store and control equipment is common in all ships, and the proposed picket ship system is designed to be compatible with SAGE. The computer aboard the ship will handle data obtained by the picket ship's own radars as well as AEW radars that relay their data to the picket ship. The capacity of the proposed Phase 2 system for the contiguous area in the Atlantic ocean is 1000 tracks at any one time. It must be possible to control up to 200 interceptions per hour from any picket ship. Allowing 10 minutes per interception, the minimum simultaneous capacity required is 35.

Three basic types of radio links are required by the data-processing equipment aboard the picket ships:

> A UHF data link to exchange detailed information between ships and AEW aircraft in a localized area defined by UHF line-of-sight transmission.
>
> A high-frequency data link between ships and/or shore stations, separated by greater distances than line-of-sight, for exchange of general information.
>
> A voice link between the intercept officer and a fighter, which will eventually be replaced or supplemented by a digital data link.

For distances less than 500 miles, tropospheric scatter should offer reliable communications. For distances greater than 500 miles, high-frequency radio is the present principal means for point-to-point communications. It is expected that by 1960 the JANET System will improve the reliability of communication over distances between 500 and 1200 miles.

The identification procedures and processes at the edge of the radar coverage, as well as within the contiguous surveillance, are as previously described.

Airborne Air Surveillance and Weapon Control

Large airborne radars for air surveillance and weapon control can be carried by aircraft, blimps and helicopters. The airborne radars are required to provide the low-altitude surveillance over the ocean areas. With further improvements and developments relative to the clutter problem, the airborne radars may have additional improved capabilities for: (1) quick substitution for land-based radars which may break down or be bombed, and (2) surveillance over remote land and ice areas.

A study* made by Lockheed for the Navy shows that the airplane is the best carrier for air surveillance alone; and that, when the carrier must have a weapons-control capability also, the blimp is competitive with the airplane, except for the effects of weather and vulnerability.

Because of the advanced state of the art for aircraft-carried radars as compared to blimps, the airborne surveillance system will be described for aircraft. In some southern areas of the contiguous zone, the weather may permit substitution of blimps.

Present aircraft, such as the WV-2 or RC-121D, are equipped with a 17-foot antenna operating at S-band for search, and an APS-45 nodding-beam X-band height finder. Over rough seas, clutter return severely limits the radar performance and the aircraft is required to fly at low altitudes to minimize it. The performance of the airborne radar system is expected to increase due to increases in the size of the antenna (up to 30 or 40 feet) and improvements in the radar. A Lockheed report** discusses the benefits to be gained with larger antennas, coupled with improved aircraft performance.

Chapter 2 has discussed an evolutionary process of bettering the radar performance. It is recommended that two radars be installed in future aircraft. The two radars will

*"Airborne Distant Early Warning System for 1960-1965." Lockheed Aircraft Corporation Report No. LR 10511. SECRET.

**"Cost of DEW Barriers Using Constellation Type Aircraft," R. Buschmann, R. Conklin, Lockheed Aircraft Corporation Report No. 10,173, 15 October 1954. CONFIDENTIAL.

either share the 30-foot antenna or use back-to-back antennas. One radar is a 4-Mw UHF (70-cm) search set, and the other is a 5-Mw S-band search and height-finding set. The large 30-foot antenna should give a radar beam that is sufficiently narrow for intercept control. This combination provides the capability to detect targets at all altitudes over rough seas and, it is hoped, over land also. The combination also provides height finding, good resolution, and resistance to enemy countermeasures.

The airplane must be designed to operate at 20,000 to 25,000 feet with 30-foot antennas. To fulfill this requirement, the present AEW&C aircraft must have a redesigned wing and possibly a power-plant change. The horizon line-of-sight at these altitudes is about 200 miles. Therefore, if the aircraft are spaced about 300 miles apart, they will obtain solid radar coverage from sea level to approximately 65,000 feet. The aircraft can determine their position to an accuracy of ±2.5 miles.

The radar information obtained by the airborne radar is relayed to the picket ship or to the SAGE System, whichever is nearer. The data can be relayed by UHF radio. Chapter 7 discusses the desirability of transmitting the data as compressed video on a UHF link.

The proposed plans call for the AEW airplanes to be within 300 miles of a picket ship or ground-based installation. UHF channels will be quite reliable for these distances. If the aircraft are operating in areas where short time delays of the order of 1 to 2 minutes can be tolerated, the JANET communication system can be used for distances up to 1200 miles.

Although provisions are made for the AEW airplanes to relay their data to intercept computers aboard the picket ships or on land, it is desirable to have a back-up capability for intercept control to supplement the picket ships and SAGE. The present aircraft have the capability of carrying 5 controllers, with each handling one or two intercepts simultaneously. Future reductions in size and weight of automatic data-processing equipment would enhance the airborne control capabilities of the AEW&C aircraft.

Introduction

VI. CONFIGURATION OF THE BASIC LAMP LIGHT SYSTEM

Section III discussed the reasons for devising several total air defense systems. Rather than presenting complete details of all the systems that have been studied, one system is thoroughly described and the others are explained as variations in Sec. VII. The basic system chosen for description has approximately the same cost as the ADR 54-60 plan.

The Basic Lamp Light System

This system is described in 4 main parts: (1) deployment of the air-surveillance and weapons-control units which have been described in Sec. V; (2) deployment of the weapons described in Sec. IV; (3) system operation, and (4) system cost.

Deployment of Air Surveillance and Weapons Control:– In order to use most effectively the weapons described in Sec. IV and to have the combat zone extend out to 650 to 700 miles, a contiguous data zone of about 1400 miles is required for high-altitude targets. Because targets have lower speeds at low altitudes, the low-altitude coverage need extend only about 1000 miles. Since intercept control and combat does not occur in the outer 700 to 750 miles of data zone, relatively low-resolution radar can be tolerated in the outer portion. In the regions where combat occurs, the radars must have narrow beams and high resolution so that the interceptors can be accurately vectored to the targets.

At the cost level of the ADR 54-60 proposal, it was not possible to have a 1400-mile data zone all around the defended areas and still have a reasonable cost distribution between weapons and surveillance. Figure 12-3 shows the resulting configuration which extends 1400 miles into the Atlantic and northeast Canada, 700 miles into the Pacific and northwest Canada, and 200 miles into the Gulf. Figure 12-3 also shows the non-contiguous early-information line from Midway to the United Kingdom, and it should be noted that the DEW line is adjacent to the contiguous data zone in northeastern Canada.

Section V has described the air-surveillance and weapons-control systems for use over land and over water. The quantities and locations of these units are described for the proposed system.

Over Land:– The high-altitude coverage over land, as shown in Fig. 12-3, represents a small increase over that of the ADR 54-60 plan. The ADR 54-60 plan will provide high-altitude surveillance over virtually all the United States and southern

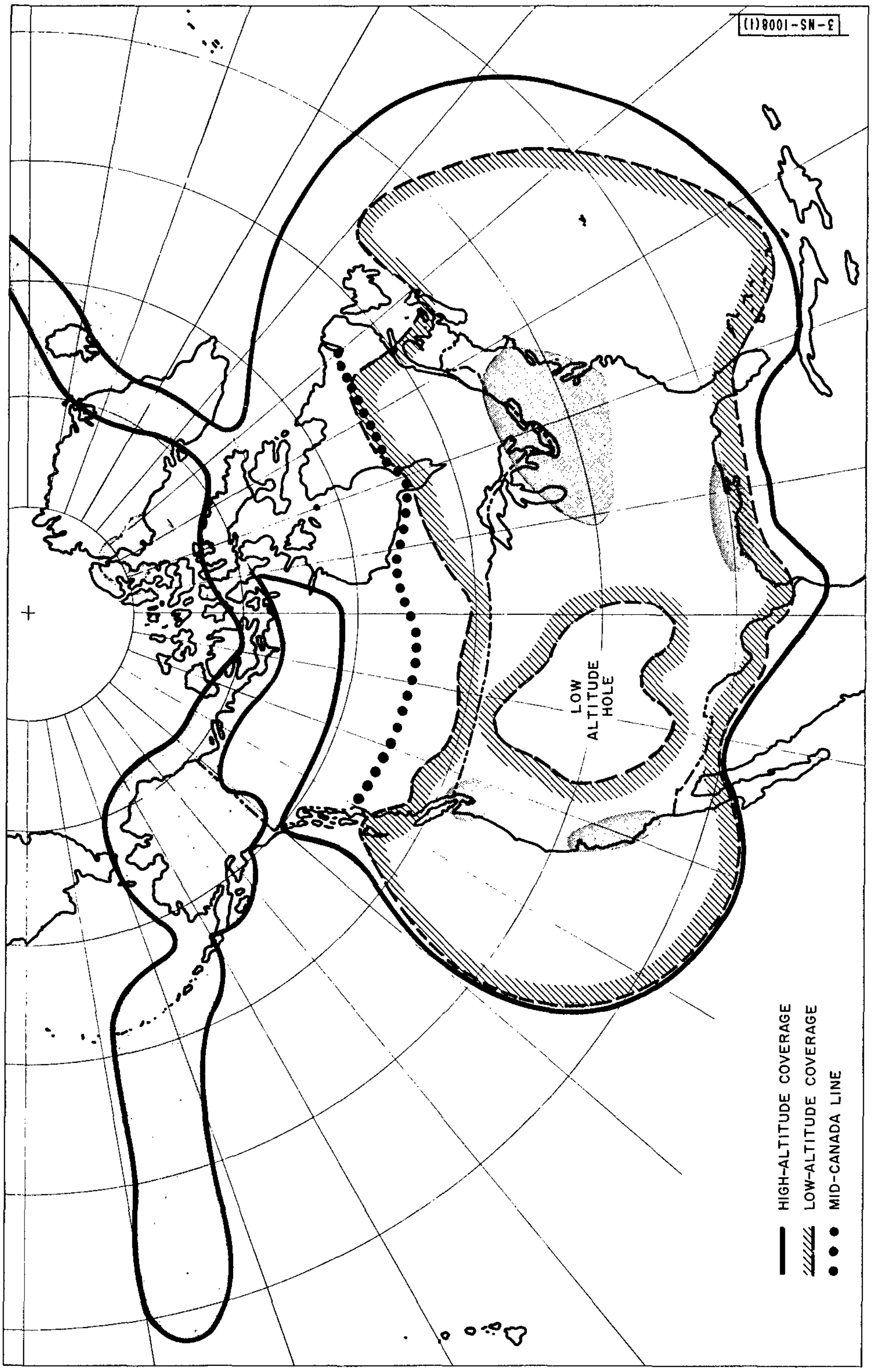


Fig. 12-3. Air defense data zone, 1960. Basic Lamp Light System.

Canada. Appendix 12-B lists the proposed locations for 10 additional long-range radars which will extend the high-altitude coverage to the boundaries shown on Fig. 12-3.

The ADR 54-60 plan does not include the Canadian proposal to extend their high-altitude coverage during the next few years, but the proposal for 10 radars is about the same number as planned by Canada. However, there is a difference in some of the detailed locations.

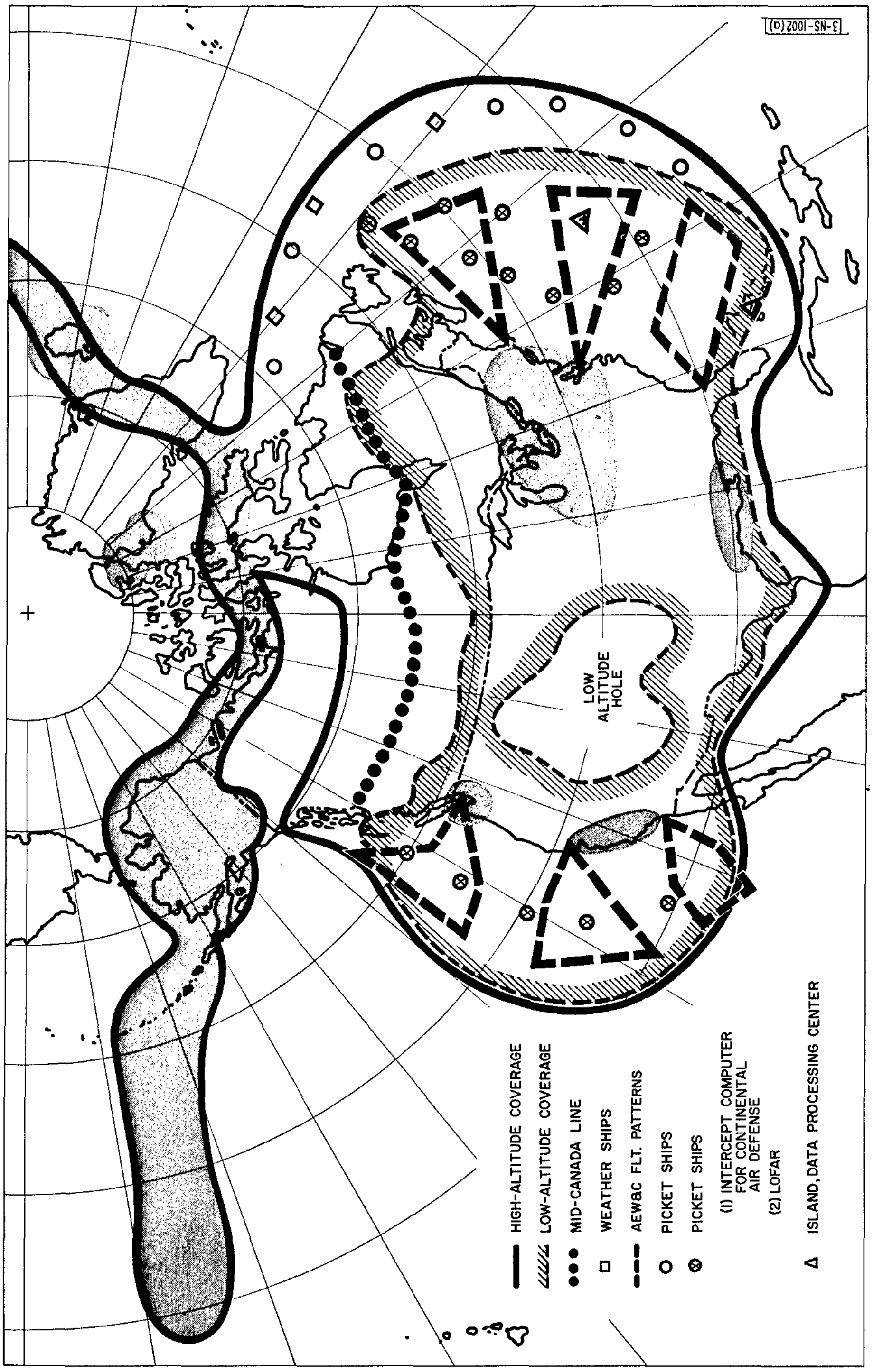
The ADR 54-60 plans for low-altitude coverage over the United States are quite extensive. Chapter 4 has indicated the need for additional gap fillers in the United States to achieve a more solid coverage in order to minimize the time that a track may have to be dead-reckoned.

Although the ADR 54-60 plan indicates gap fillers in southern Canada, the extent of this coverage is small. Unfortunately, the number of railroads and roads that permit easy access to the gap-filler sites above the 50th parallel in Canada is very small, therefore to locate gap fillers every 50 to 80 miles will be a difficult task. Even so, it is necessary to locate 75 additional gap fillers in northern Ontario and Quebec to extend the low-altitude coverage out to about 600 miles. This will then provide solid low-altitude coverage in the area south of a line running from Winnipeg to the mid-Canada line at James Bay, along the mid-Canada line to Knob Lake, and then south to the St. Lawrence River. Appendix 12B discusses some of the additional details relative to the gap fillers.

The data processing to link all the radar sites and to perform weapon control has been discussed in Sec. V.

Over Water:– The air surveillance over the ocean areas, as shown in Fig. 12-3, is obtained by a combination of picket ships and airborne radars. Details of the picket ship deployment and the AEW flight patterns over both the Atlantic and Pacific oceans are presented in Appendix 12-C, which is summarized here. Figure 12C-1 from that appendix is reproduced on p. 23 for the convenience of the reader.

Both high- and low-altitude radar coverage are obtained by the airborne radars, which are flown at approximately 20,000 feet. The aircraft are operated from mainland bases and fly a round-trip pattern that provides solid surveillance out to 1000 miles in the Atlantic and 700 miles in the Pacific. Each pattern in the Atlantic is about 2300 miles long and each pattern in the Pacific is about 1800 miles long. The extent of the seaward coverage is limited only by the range of the airplane. Using a back-up factor of



(Reproduced from Appendix 12-C)

5 aircraft required to keep one continuously on station, 105 aircraft are required for the Atlantic and 90 are required for the Pacific.

As noted in Sec. V, the data obtained by the AEW aircraft are used by the naval data-processing system aboard the picket ships and by the SAGE System on land. Since these aircraft operate predominantly in the combat zone, it appears very desirable to have some limited intercept-control capability aboard each AEW airplane to supplement the picket ships and SAGE System.

The location of the picket ships is governed by two considerations. First, those picket ships that are within 1000 miles of the shore provide redundant high-altitude coverage, but they are so located to function as control centers for the air battle. The advantages for the redundant coverage are the same as those discussed for the land-based radars in Sec. V. One row of pickets is located parallel to the shore and about 350 miles out, and the second row is about 700 miles out.

The second consideration is that the picket ships that are beyond the coverage provided by the AEW are located to extend the contiguous data zone and need not have the same data-processing equipment, such as intercept computers, that the other pickets have. In the Atlantic, which is the only place that picket ships are located 1200 miles from shore, three of the U. S. -operated Atlantic weather stations have been used. If these weather station ships are equipped with high-performance radar sets and their location moved only 50 to 100 miles, they will fit in very well with this outer perimeter of radars.

Sixteen picket vessel stations (not including the 3 weather station ships) are used in the Atlantic and 5 in the Pacific.

Weapon Deployment:– The numbers of active weapons used in the basic system for the contiguous battle zone in 1960 are shown in Table 12-III. This number of weapons is within the reasonable production capability of the United States and Canada, and, as mentioned previously, the development and testing of these weapons are well under way.

These interceptors and surface-to-air missiles have been deployed to fulfill the objectives mentioned previously in Sec. III, namely, the northeast United States and southeast Canada heartland receives approximately 70 per cent of the weapon strength. Most of the balance of the interceptors and local defense surface-to-air missiles are deployed to defend the Pacific northwest and the San Diego to San Francisco region. The remaining interceptor squadrons and missile battalions have been deployed to defend SAC bases and a few specific industrial targets in the midwest and south. The

TABLE 12-III 1960 WEAPONS			
Type	Total Number per Squadron or Battalion	Number of Squadrons or Battalions	Squadron or Battalion Change from ADR 54-60 Plan
Medium-Range Interceptors (F-102B)	27.5	100	25 increase
Medium-Long-Range Interceptors (F-101B)	27.5	50	41 increase
Medium-Range Canadian Interceptors (CF-105)	27.5	10	–
Long-Range Interceptors	27.5	0	29 decrease
Bomarc Missiles	120	0	53 decrease
Nike Missiles	214	125	25 increase

interceptor and surface-to-air missile deployments are shown in Figs. 12-4 and 12-5, respectively. In order to use their larger area coverage ability, medium-long-range interceptor squadrons have been placed inland from the Pacific coast. The medium-range interceptor squadrons are used for Pacific coast defense. It should be pointed out that only the interceptor bases discussed in ADR 54-60 have been used. These bases are those now in use or well along in the construction of additional facilities.

The details of the numbers of squadrons of airplanes at each base and the surface-to-air missile locations are given in Appendix 12-D.

The augmentation forces mentioned in Sec. IV are deployed in accordance with the ADR 54-60 plan. These fighters are used in the southern area of the United States where active CONAD defense is weakest. By making use of the early-information line proposed by Lamp Light, it is believed that a sufficient number of these weapons can be brought to readiness to augment the CONAD interceptors in defeating a sneak attack against SAC bases located in this area.

System Operation:– This section will define the possible operation of the Basic Lamp Light System for a two-pronged mass air attack at high altitude against North America from the USSR. The combat zone and the data zone for the Basic Lamp Light System

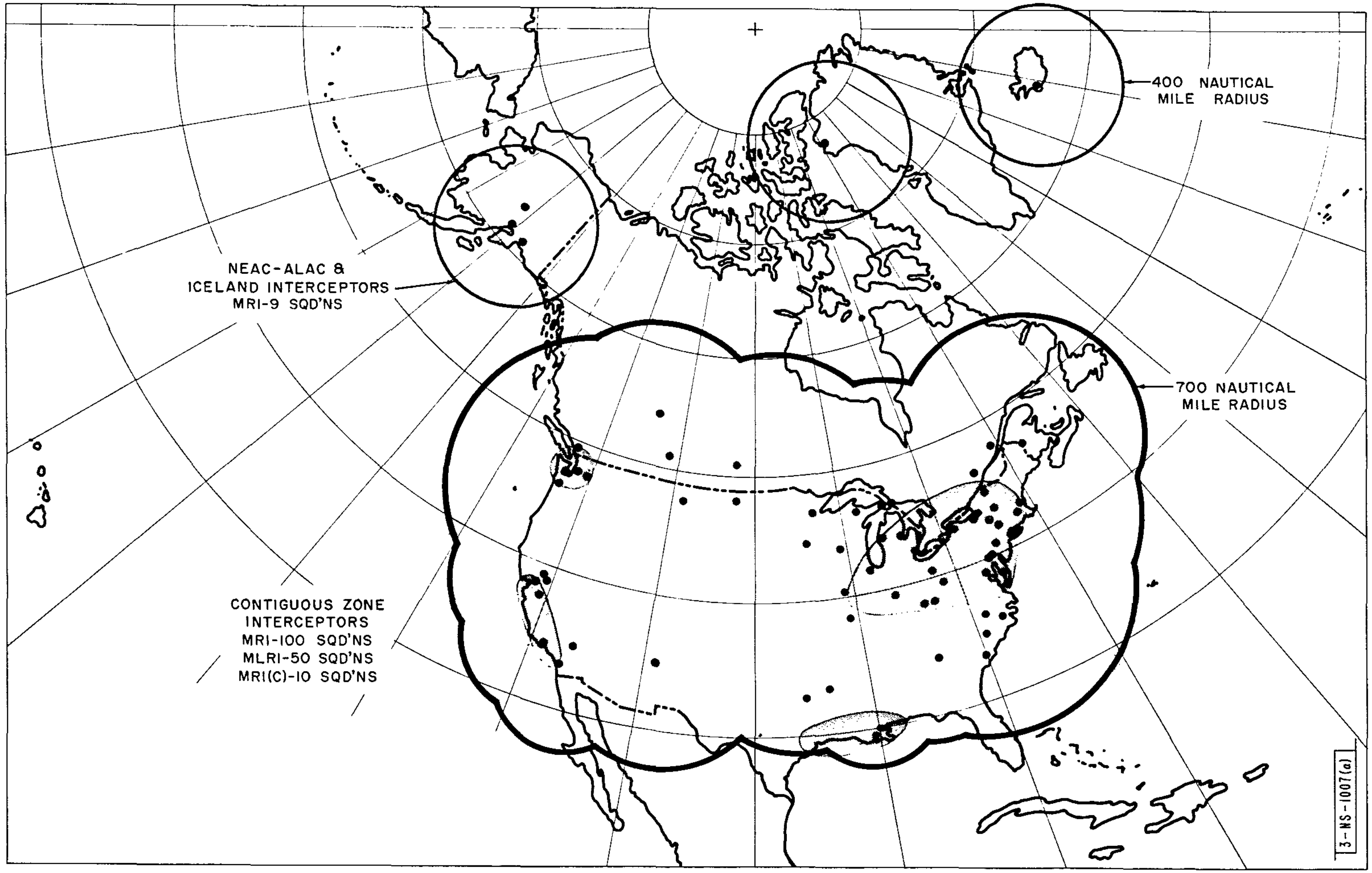


Fig. 12-4. Interceptor deployment and operational combat radius — Basic Lamp Light System.

Fig. 12-5. 1960 local defenses — Basic Lamp Light System.

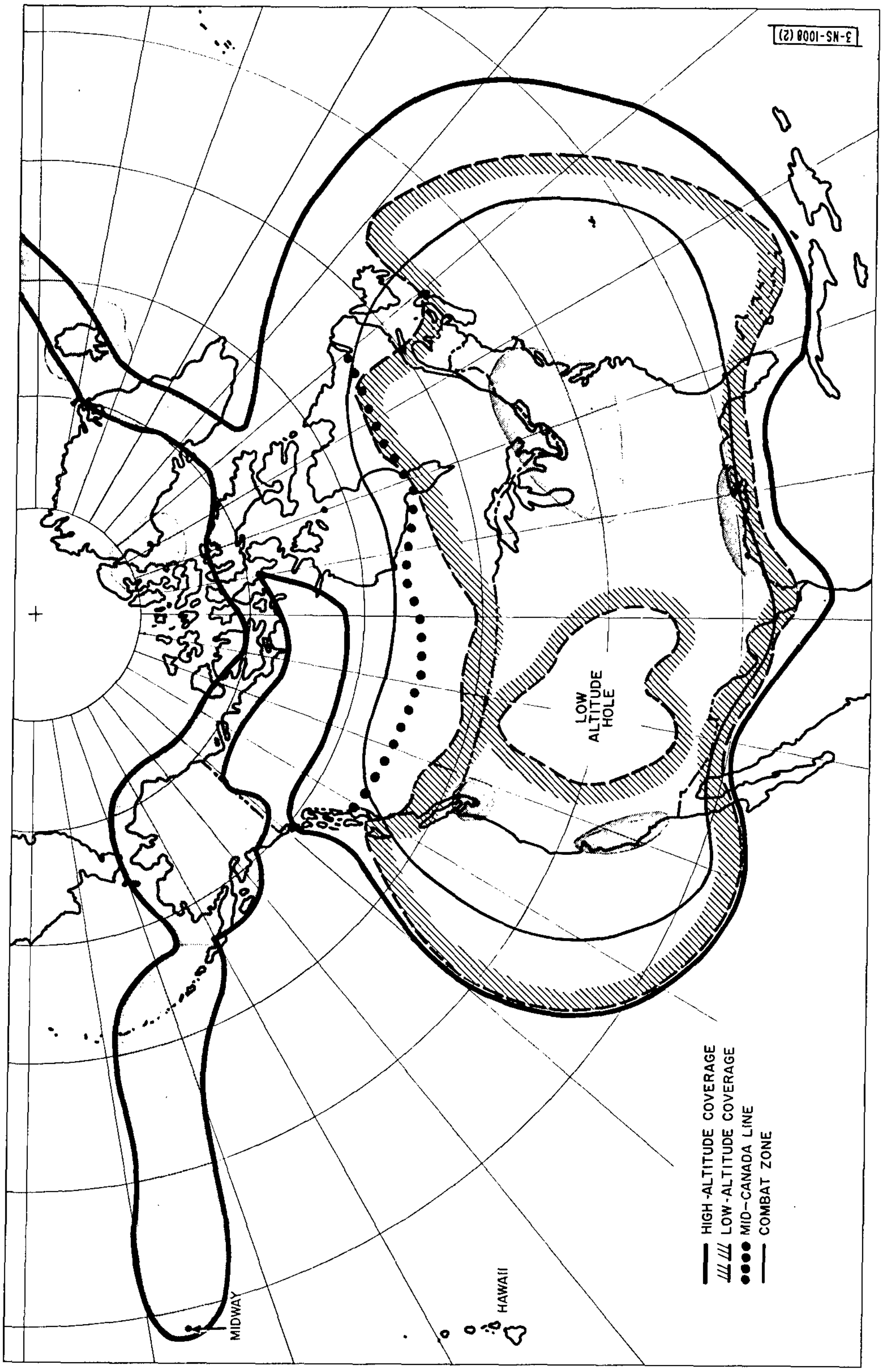


Fig. 12-6. Air defense data and combat zones, 1960 — Basic Lamp Light System.

are shown in Fig. 12-6. One attack route is from the Atlantic to New York, Boston and Philadelphia. The other attack route is over the North Pole, via Hudson Bay to Chicago and Detroit. Figure 12-7 shows the attack routes and other information to be explained later. The above attack routes appear quite probable from the USSR standpoint, and the system operation and effectiveness for such an attack has been studied in some detail.

Attack from the Atlantic:-* When the raid crosses the non-contiguous early-information line between Greenland and the United Kingdom, the identification processes described in Chapter 8 take place (crypto-coding for military aircraft, procedural methods and safety beacon for commercial aircraft). The raid would be identified as hostile, at the early information line, by picket ship or shore radar station, by these identification methods and by its large size. This information would be relayed to the nearest SAGE center and naval command center by radio using the techniques discussed in Chapter 6. The RCAF and USAF air defense systems would be alerted and the interceptors and local defense missiles would be brought to readiness. It is reasonable to assume the following availability schedule for air defense interceptors from a squadron of 25 aircraft, even when there is no early warning.

4 aircraft in	5 min.
4 aircraft in	25 min.
4 aircraft in	50 min.
3 aircraft in	90 min.
2 aircraft in	120 min.
17 total out of 25	

The remaining 8 aircraft would be "down" for maintenance or on training missions and are not assumed to participate in the initial battle.

It would take the enemy raid, flying at 450 knots, about 3 hours to reach the edge of the contiguous zone. During this time, information on course and approximate raid size would be relayed from the merchant ships equipped with Chipmunk-type radars as described in Chapter 13.

When the raid enters the contiguous cover (1400 n. mi. from shore at high altitude, 1000 n. mi. from shore at low altitude), the information is relayed to shore via long-distance communication links from the outermost line of picket ships. The weapons director at the SAGE center then scrambles some of the MLRI to meet the incoming raid. The number of aircraft scrambled would of course depend on the over-all air

*See Appendix 12-E for separate discussion of the Navy's role.

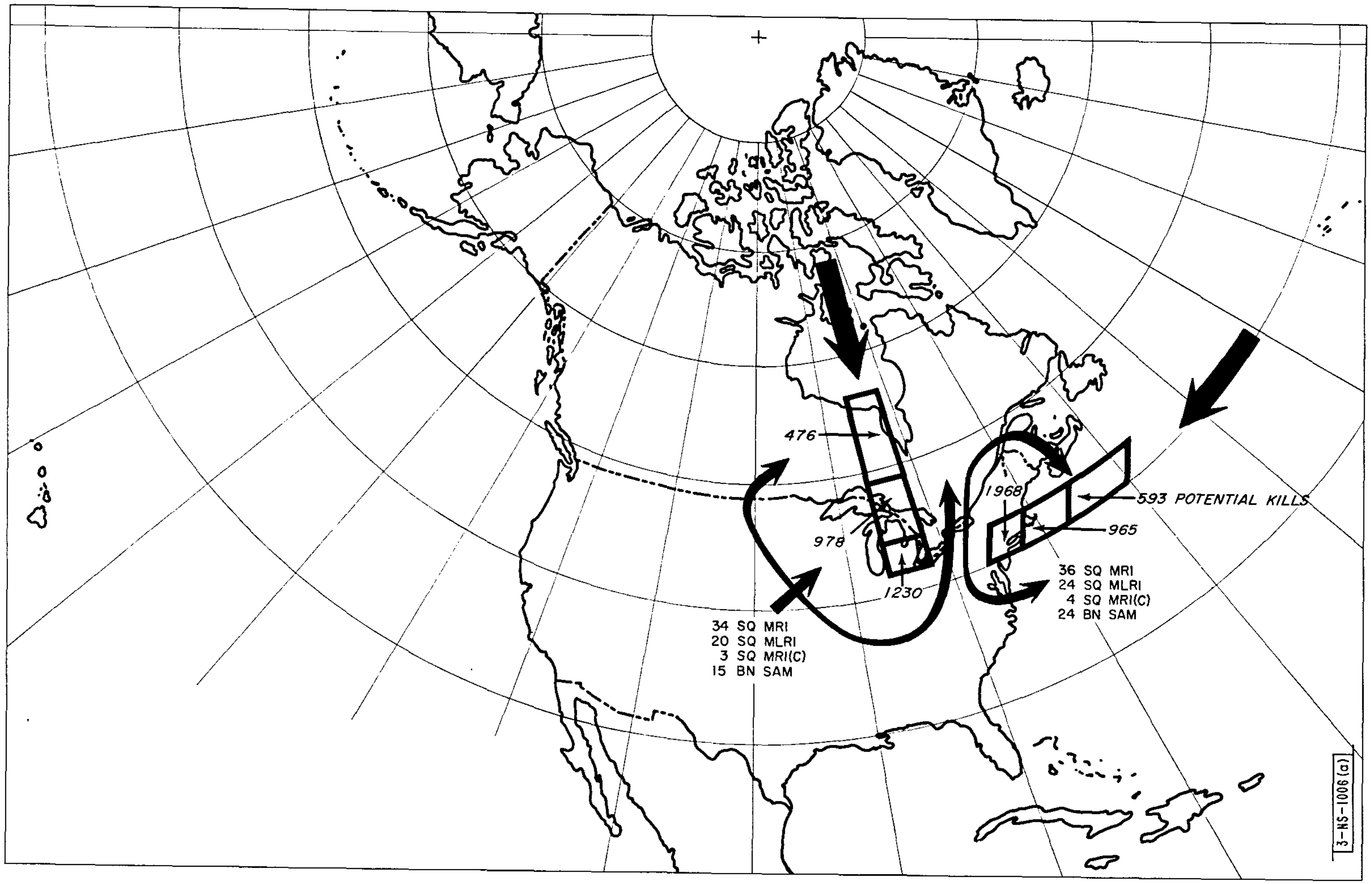


Fig. 12-7. System operation – Basic Lamp Light System.

situation which would be monitored by the division commander. A profile cut through the contiguous cover is shown in Fig. 12-8. The radar cover and bomber time-distance history in penetrating the zone is shown.

The filtered data on raid size, altitude, course and speed from the picket ship's (or AEW&C aircraft's) radar is processed aboard a picket ship and relayed to the naval shore command and SAGE System by a high-frequency digital data link. As the raid progresses shoreward from the outer line of picket ships (1200 n. mi. from shore), the raid is tracked continuously by the AEW&C aircraft and inshore picket stations. When the incoming raid is in an AEW&C's radar coverage, the compressed video from the airborne radar is sent to the nearest inshore picket ship by UHF data link. An AEW&C aircraft is never more than 300 n. mi. from a picket ship, thus UHF communications should suffice. The SAGE control center receives from the pickets filtered data about the incoming bomber raid. The initial headings for each intercept track are transmitted to the interceptors from SAGE by a discrete-address digital data link. When the interceptors reach the limits of SAGE control, intercept vectors are given by the nearest picket, and filtered data about the outgoing interceptors are relayed to the SAGE center by the picket.

As the raid and interceptors converge, the air battle control is localized to the nearest picket. One possible attack course is for the interceptors to be vectored on a reciprocal heading to the incoming bomber raid, (displaced laterally 20 to 50 miles) and at the proper time given instructions to turn into a lead-collision heading with the raid. When AI radar lock-on occurs, guidance instructions to the interceptor pilot are received from the AI radar and the pilot flies the aircraft manually (or with control surface tie-in from the AI radar) to the firing position. After weapon launch, an appropriate escape turn is made when using Ding Dong-type armament.

Since the fighters are equipped with multiple-pass capability (four passes for the MLRI and three passes for the MRI), re-attacks are possible. If the raid is diffuse enough, the picket ships can keep track of the interceptors after the initial attack and re-vector the interceptors for the next pass. In the case of a highly congested air battle, however, the interceptors will have to re-acquire targets after the initial pass without the benefit of ground control. The need for the longer-range AI radars for re-attacks is IFF () thus clearly indicated.

(After the interceptors' armament has been expended, the interceptors would return to base through corridors away from the estimated raid aiming points.)

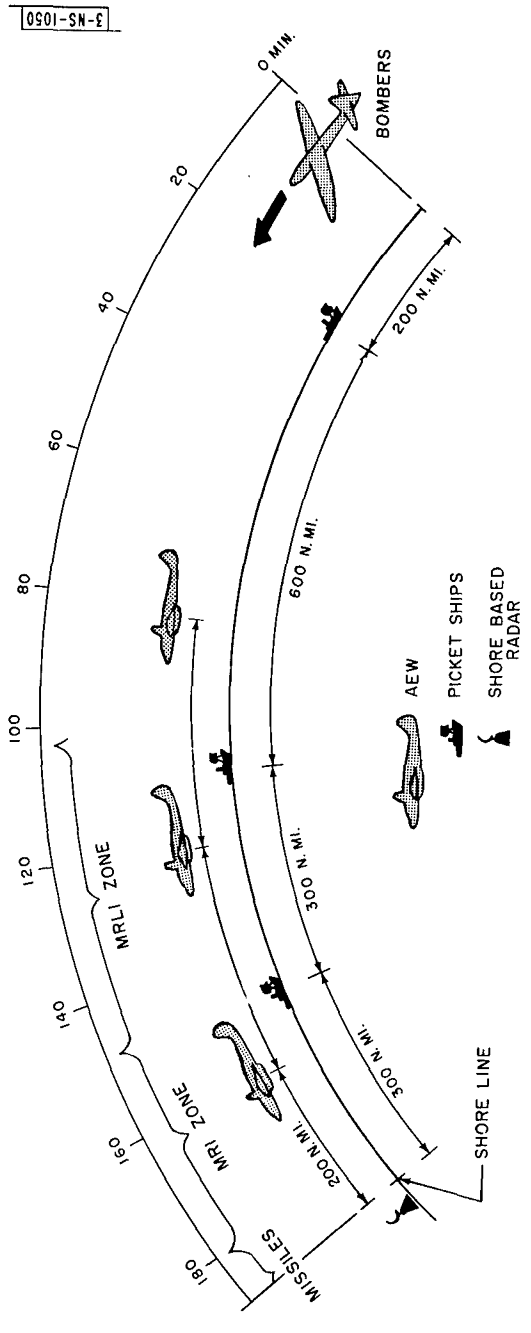


Fig. 12-8. Contiguous data zone — over-water profile. Basic Lamp Light System.

As the raid progresses to about 200 miles from shore, the air battle control is transferred completely to SAGE including the final intercept vectoring. When the raid comes to within about 70 miles of the target areas, the control of the battle is transferred to the Antiaircraft Command's local missiles. SAGE would continue to provide information to the AA Command. The missile battalions would operate on a "guns free" status with interceptors excluded from the air battle in this region.

Figure 12-7 illustrates the possible commitment of weapons to the Atlantic coast raid described herein. As seen, the interceptors are drawn from the bases east of Allegheny mountains. Figure 12-7 also shows the number of interceptor squadrons and missile battalions committed to the attack as well as the potential kills in each battle zone. The potential kills are determined from the data given in Appendix 12-A and are not the expected kills. The expected kills are lower because of the confused nature of this concentrated air battle. A given enemy flying object may be assigned to and fired upon by several different interceptors or surface-to-air missiles before a kill is recognized.

Figure 12-8 shows the dimensions of the contiguous battle zone. For this attack, the enemy is under constant fire for 700 n. mi. and 1 1/2 hours.

Two of the possible ways to extend the combat in the contiguous zone beyond 700 n. mi. are:

> The use of naval carrier-based aircraft operating in the contiguous zone. This possibility is discussed further in Appendix 12-E.
>
> Interceptor in-flight refueling. Some medium-long-range interceptors equipped with "buddy" in-flight refueling tanks could be scrambled to the outer portion of the contiguous zone after the non-contiguous warning line is crossed. The operation would consist of two MLRI's, flying as an element, one of which is the refueler aircraft, the other the combat aircraft. The combat airplane refuels at about 600 n. mi. from base and can then proceed to 1000 n. mi. from base, for example. At this distance, about 1 1/2 hours of loitering time is available, plus combat time and sufficient fuel to return to base with normal reserves.

A high probability of being able to intercept the enemy raid at these distances is believed possible for the following reasons:

> For the above example, the interceptors can fly 400 n. mi. inside the edge of the contiguous cover with 1 1/2 hours of time on station. They can be vectored up to about 450 n. mi. laterally when the raid enters the contiguous cover and still meet the raid 1000 miles from shore.

> By making use of the general-surveillance information from merchant ships in the area between the warning line and the contiguous cover, the interceptors can more nearly position themselves to meet the incoming raid.

Neither the carrier-based fighters nor the "buddy" in-flight refueling concept were considered for purposes of numerical evaluation of system effectiveness, however, because of lack of time.

Attack Route Over Canada:– The attack via the North Pole and Hudson Bay to the midwest portion of the heartland would be handled in much the same way as the attack via the Atlantic except for the following major differences.

The defense system would not be alerted by a non-contiguous early-information line, since for this route the information line is adjacent to the contiguous zone. The extent of high-altitude contiguous cover is again about 1400 n. mi. from the heartland. Combats can begin 700-800 n. mi. from Chicago and Detroit. However, although slightly longer decision time is assumed when there is no early information, the fact that some RCAF and USAF interceptors are based fairly far north (Sault Ste Marie, Mich; Winnipeg, Manitoba, etc.) means that the deeper penetration of the raid before the fighters are committed is offset by the decrease in the distance they must travel before combat.

The data-handling system proposed by Canada (Cadar) would be used in northern Canada. A Cadar computer would be located at each long-range radar site. Therefore the radar site would serve the same function as the picket ships in the ocean. Communications would be by land lines where possible. Radio techniques would be used in the absence of land lines. SAGE would be extended into southern Canada for this proposed system and be compatible with Cadar. A profile cut through the contiguous zone is shown in Fig. 12-9 as well as the bomber penetration-time history for a high-altitude attack.

It can be seen that close coordination between RCAF and USAF Air Defense Commands must be maintained, as is now the case, in order to conduct the air battle most effectively.

Figure 12-7 shows the possible commitment of weapons to the over-Canada raid, including the number of interceptor squadrons and missile battalions brought to bear. The potential kills are also shown. Thus, for a coordinated attack against the east and midwest (New York, Boston, Philadelphia, Chicago and Detroit), 121 interceptor squadrons and 39 dual surface-to-air missile battalions could be committed to the battle.

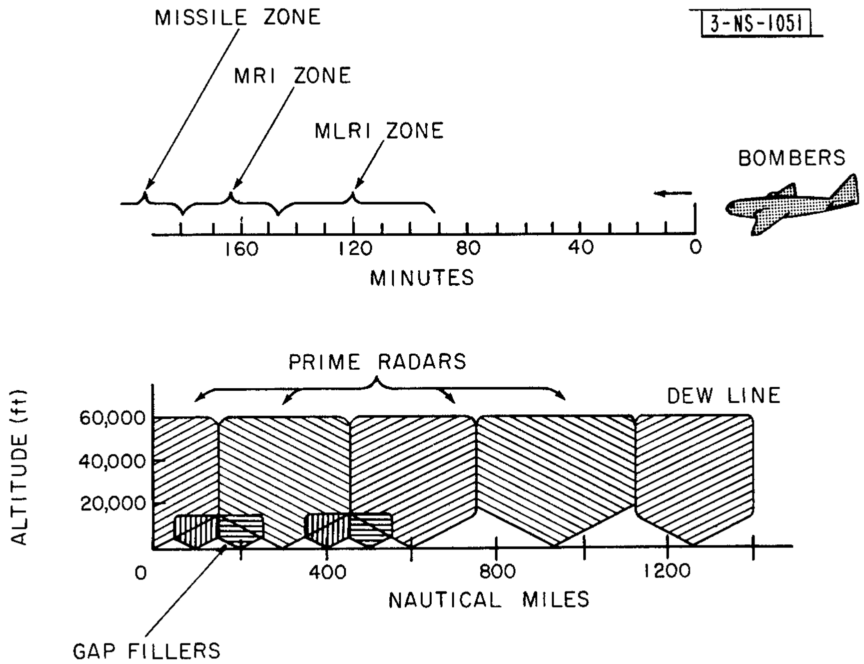


Fig. 12-9. Typical section of contiguous data zone from the heartland northward – Basic Lamp Light System.

The raid that appears most difficult to defeat is the so-called "Horror Raid." This raid is a mass air attack consisting of bombers, decoys and air-to-surface missiles. A typical raid might consist of about 1000 of the above-mentioned flying objects in a block of airspace 40 miles wide, 2 miles high and 225 miles long. The flying objects in this block would be randomly distributed with about 3- to 4-mile spacing. Thus small-yield atomic rockets would have a low probability of killing more than one flying object. Saturation of the defenses appears to be the most serious problem. However, for example, in order not to exceed the data-handling capacity of the system, 4 interceptors could be vectored out together and handled as one track. The enemy raid could likewise be arbitrarily broken into elements for traffic-handling purposes. It appears that reattack against this raid by the interceptors would have to be done by the interceptor pilot alone, making use of the facilities (IFF, navigational aids, AI radar) in the airplane. Only a minimum of assistance from ground control would be available since initial attacks requiring close control by succeeding waves of interceptors would be in progress.

what of weps

The use of a few large-yield atomic warheads at the extremities of the MLRI zone appears desirable in order to disperse the raid if the attack is massed, or to act as a deterrent to such a formation.

System Cost:- The cost of the Basic Lamp Light System has been estimated by the cost procedure used by the Air Defense Command. Furthermore, the unit costs as determined by ADC were used wherever possible. A summary of the costing method is presented.

All the costs that enter into an air defense system have been broken down into 3 main divisions: weapons; air surveillance and weapons control; and external support. For each of these 3 categories, capital and operating costs are determined separately. The weapons are discussed in Sec. IV, and the air-surveillance and weapons-control items are discussed in Sec. V. Higher echelon costs within ADC are included in weapons and surveillance. External support represents a proportion of the operating costs of other nontactical major commands applicable to air defense.

Capital costs include the following: major equipment, organizational equipment, stocks and spares, transportation of equipment, personnel training and travel, recreational facilities.

Operating costs include the following: maintenance and replacement of equipment, transportation of replacement equipment, personnel pay, training, and travel, fuels and lubricants, maintenance of recreational facilities, support personnel, training arms and aids.

The costs of the system are cumulative through mid-1960. Capital costs are a function of the amount of equipment purchased. Total operating costs are a function of the amount of equipment and the rate at which it is entered into the system. For a dynamic system which has constant changes in the amount of equipment on hand, the annual operating costs of each item are computed by multiplying the average number of units on hand during the year times the unit annual operating cost.

The Basic Lamp Light System, which is costed in detail in Appendix 12-F, is calculated by adding or removing items from the ADR 54-60 plan costs. Table 12-IV presents a summary of the costs and a comparison with the ADR 54-60 plan.

TABLE 12-IV
COST SUMMARY
(In millions of dollars)

	Basic Lamp Light System		ADR 54-60	
	Capital	Operating	Capital	Operating
Surveillance	4,042	3,592	2,886	3,337
Weapons	18,356	11,189	18,515	11,030
Command Administration & External Support	23	6,478	23	6,353
Total	22,421	21,259	21,424	20,719
Grand Total	43,680		42,143	

VII. VARIATIONS FROM BASIC LAMP LIGHT SYSTEM

Scaled-Up and Scaled-Down Variations

The Basic Lamp Light System described in this chapter was costed at $43.7 billion. This cost is approximately the same as the ADR 54-60 proposed cumulative budget. However, since the above funds are proposed expenditures only, and to provide an evaluation of system combat effectiveness at different cost levels, variations of the Basic Lamp Light System were also designed at budget levels of $37.2 and 50.7 billion. Appendix 12-F gives the detailed cost breakdown.

In designing the system for the high budget level, the shortcomings of inadequate cover on the Pacific coast and on the southern flank of the United States, compared to the heartland, were eliminated. In addition, the data-zone gap in the northwestern portion of Canada in the basic system was filled. Additional weapons were also purchased. The number of interceptor squadrons and local missile battalions was increased about

32 per cent. The same number of medium-long-range as medium-range interceptor squadrons were added. This results in a higher percentage increase in MLRI squadrons, which is justified in view of the increased data zone available for their use.

For the $37.2 billion budget level, the extent of the contiguous cover around the heartland only was reduced. The number of interceptor squadrons and missile battalions was reduced approximately 32 per cent from that of the basic system. The same number of MLRI as MRI squadrons was subtracted, resulting in a larger percentage reduction in MLRI strength. This again is justified in view of the lesser data zone.

Table 12-V summarizes the important features of the scaled-up and scaled-down variations compared to the Basic Lamp Light System. As can be seen, the elimination of Bomarc and the long-range interceptor from the Lamp Light system releases substantial funds ($ 7.4 billion) to provide more surveillance and less-costly weapons than the ADR 54-60 plan.

The resulting data and combat zones for the Basic Lamp Light System and the scaled-up and scaled-down versions are shown in Figs. 12-6, 12-10, and 12-11, respectively, for easy comparison.

Missile Perimeter Variation

Another variation, considered only for the heartland, was the substitution of additional surface-to-air missiles for a portion of the interceptor force, without changing the over-all capital investment. The cost of this additional missile perimeter is approximately $ 2.1 billion including capital costs and 1.5 years' operation. This is equivalent to about 22 interceptor squadrons. The additional missiles were placed to form a line or perimeter immediately outside the coverage of the planned U. S. local-defense missiles, and the principal Canadian cities.

Placement of the perimeter in this fashion left a few relatively small interior areas uncovered by planned local-defense missiles. These areas were covered by additional installations so that the enemy would be denied freedom of movement anywhere inside the perimeter defense.

This combined missile defense of the heartland is illustrated in Fig. 12-12. Appendix 12-G contains additional detailed information.

The region off the Atlantic coast was assumed to be covered by missile ships, located approximately 100 miles offshore. These would presumably be converted Liberty Ships. It is possible, however, that several of the offshore sites could be small man-made islands or special Texas Towers rather than ships.

TABLE 12-V

CONTIGUOUS SYSTEM AT DIFFERENT COST LEVELS†

	SURVEILLANCE								WEAPONS					
	Extent of High Altitude Cover													
Cost Level (in billions of dollars)	Atlantic (n.mi.)	Pacific (n.mi.)	Canada (n.mi.)	Gulf (n.mi.)	No. of Long-Range Radars	No. of Gap Fillers	No. of Picket-Ship Stations	Total No. of AEW (incl. back-up)	MRI Squadrons	MLRI Squadrons	MRI (C)* Squadrons	SAM (BNS)	LRI** Squadrons	Bomarc** Squadrons
$50.7	1400	1400	1400	600	279	498	37	375	125	75	10	185	0	0
$43.7	1400	700	1400 (NE) 700 (NW)	150	274	498	27	270	100	50	10	125	0	0
$37.2	1000	700	1000 (NE) 700 (NW)	150	271	498	23	245	75	25	10	85	0	0
ADR 54-60 $42.1	475	250	550	200	238	423	14	206	75	9	10	100	29	53

†Including non-contiguous information line in all cases.

*The Canadian MRI squadrons were not included in the cost levels shown.

**The capital and operating costs of the LRI and Bomarc squadrons through 1960 is $7.4 billion in the ADR 54-60 plan.

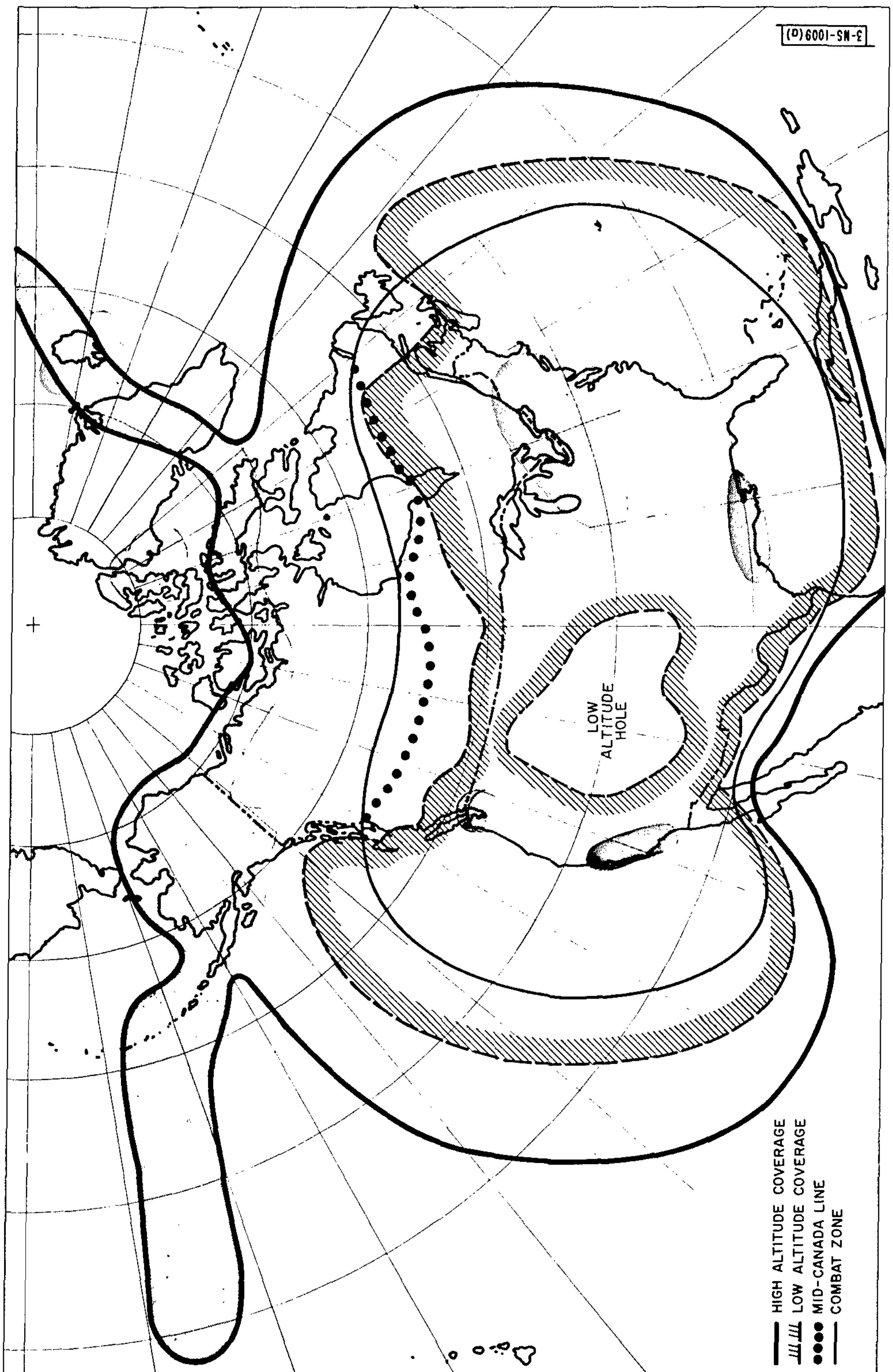


Fig. 12-10. Air defense data and combat zones, 1960. Scaled-up variation. Cost level $50.7 billion.

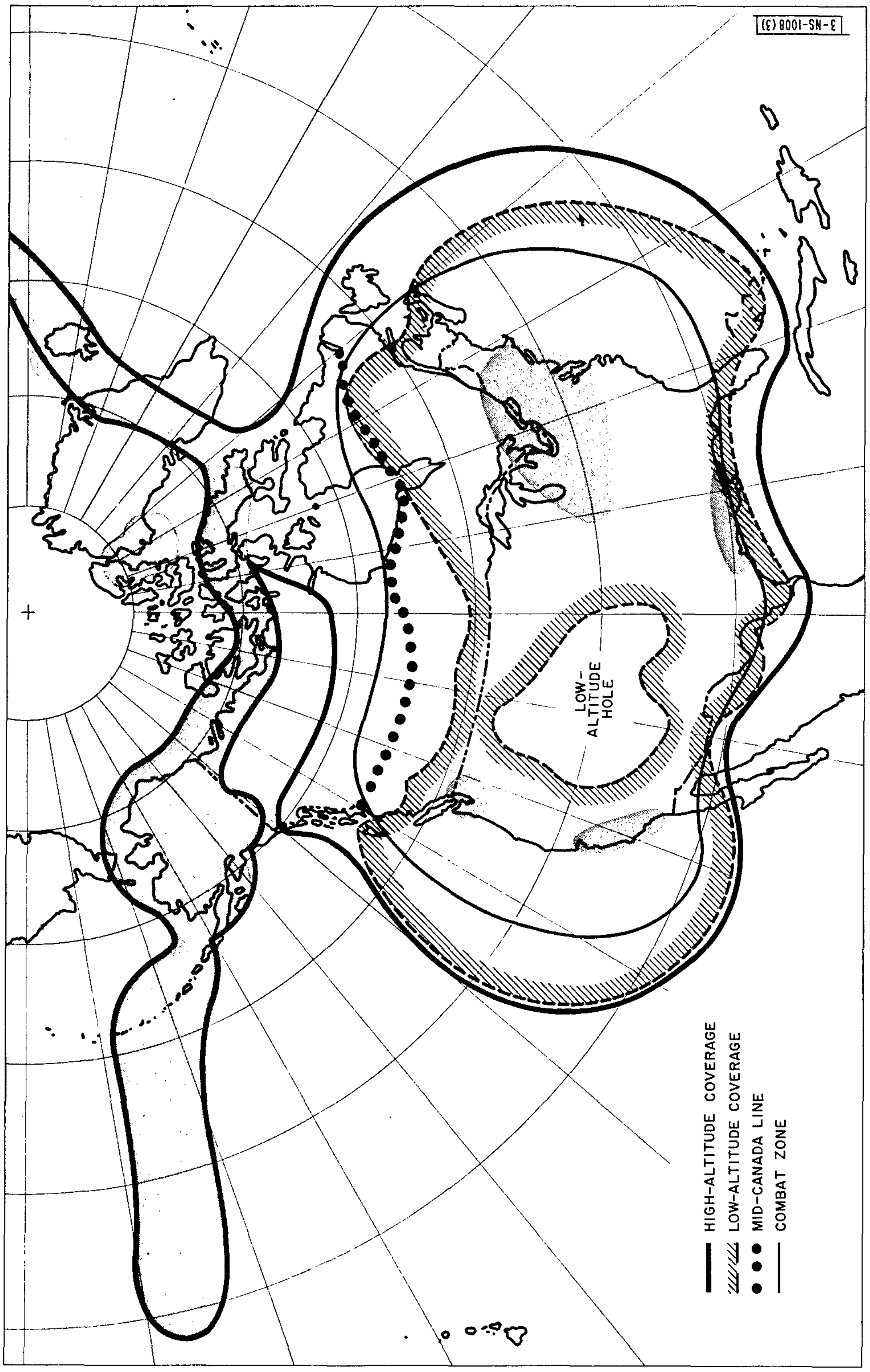


Fig. 12-11. Air defense data and combat zones, 1960. Scaled-down variation. Cost level $37.2 billion.

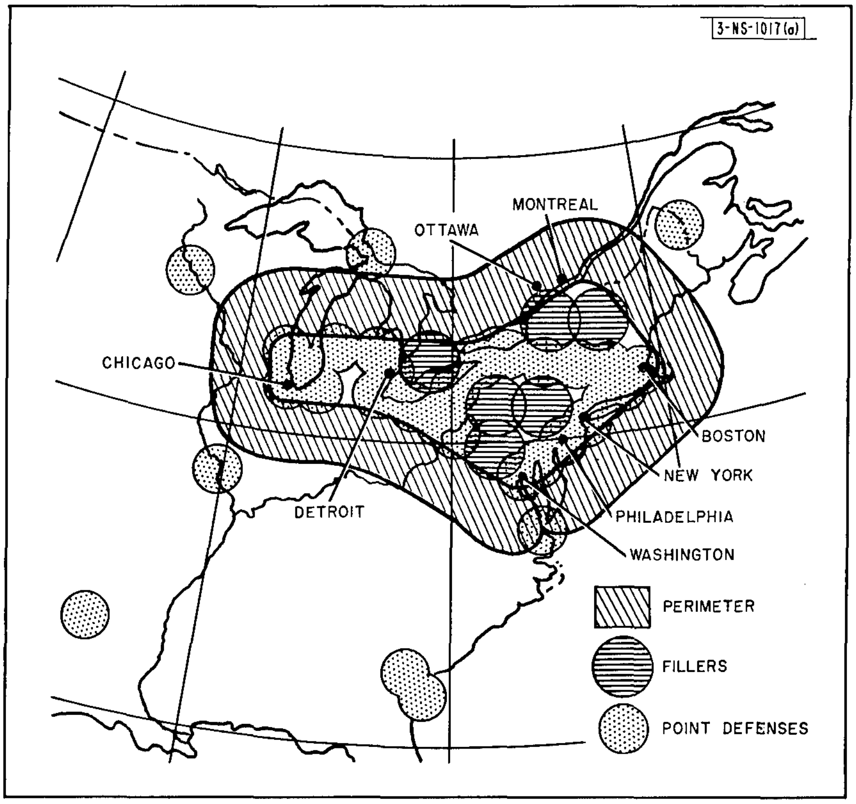


Fig. 12-12. Missile perimeter variation.

Interceptors would be based in the missile-defended area, but they would proceed outside the area for combat. This would minimize the problem of coordinating interceptors and defensive missiles. After combat, the interceptors would enter the missile-defended area through corridors away from the raid, or be diverted to alternate bases outside the defended area, thereby permitting the missiles to operate on a "guns free" basis.

Qualitative advantages of this concept include:

> By engaging targets about 200 miles from defended cities, it combats the use of simple, short-range air-to-surface missiles and decoys.
>
> By encircling the heartland and filling out the internal missile coverage, it causes the enemy to minimize flights of his bombers in this region.
>
> Launching sites and operating area of the perimeter missiles are away from principal cities, making the use of atomic warheads much less objectionable. This also avoids the problem of procuring real estate in the suburbs of defended cities.
>
> It gives important extension to the defenses against supersonic, very-high-flying pilotless or manned bombers.
>
> By introducing another type of defense that must be crossed by attacking bombers, it compounds the enemy's problem of confusing our defenses by countermeasures.

Principal qualitative disadvantages are:

> If the enemy attacks only a few cities in the heartland area, only a few of the total number of sites are able to engage the attacking force.
>
> The land sites, being a substantial threat to the attacker and also being relatively compact, may be bombed out by the enemy. The sea sites are subject to bombing and possibly to torpedoing as well.
>
> The combat airspace available for the medium-range interceptors is substantially reduced.

Minus Early-Information Variations

The non-contiguous early-information line which is present in the Basic Lamp Light System is costed at about $1.0 billion capital and operating cost through 1960. The many advantages of this line are discussed elsewhere in this report; in the present context, we are concerned specifically with the effect of the line on the combat effectiveness of the system. The information line's effect on weapon effectiveness in the contiguous zone is based on the time afforded to bring the available interceptors to full readiness prior to penetration of the contiguous zone. After the noncontiguous sea wings of the line are crossed by the enemy (for example, between the United Kingdom

and Greenland), it takes about 3 hours for the enemy to fly from the information line to the edge of the contiguous zone for a raid aimed directly at New York. If the raid is identified as hostile upon crossing the information line, all 17 of the available interceptors from a squadron can be brought to readiness prior to penetration of the contiguous zone. Consequently, when the contiguous zone is penetrated, the MLRI's can be scrambled in such a manner so as to provide a more effective commitment against the raid. If the interceptors are not alerted until the contiguous zone is penetrated – as would be the case without the information line – then only a few of the airplanes from a given squadron can meet the raid at the maximum extent of the interceptors' combat radius. Therefore, the resulting air battle has a low interceptor-to-bomber ratio initially, and this ratio increases as the enemy raid penetrates further. A constant interceptor-to-bomber ratio is more desirable.

The times required to evacuate operational aircraft of the Strategic Air Command have been estimated. These estimates are taken from briefings given Project Lamp Light by SAC and other representatives of the Department of Defense. The times given below are reckoned from the instant at which a decision has been made to evacuate. Decision and communication time is additional. It also should be noted that 15 per cent of SAC aircraft are not on SAC bases at any one time.

Time after Decision to Evacuate (hours)	Per Cent of Flyable Aircraft Evacuated
0	15
1/2	15
1	36
1 1/2	57
2	79
2 1/2	100

The above tabulation gives the times required by about 1957 and assumes that certain changes are made to improve the present situation. SAC also has plans further to reduce this warning time.

It can thus be seen that, with about 3 hours' warning (including identification, communication and decision time), most of the SAC aircraft can be evacuated from their bases. The non-contiguous early-information line provides much more than the required 3 hours. Without the line, however, there is inadequate warning from the south and west to evacuate more than about 40 per cent of SAC.

Some of the major disadvantages of the early-information line as proposed are:

> False alarms by unidentified friendly aircraft or probing missions by the enemy which would tend to negate the value of the line.

The political difficulty of enforcing identification procedures in the ocean areas and the possibility of inciting the USSR to attack by placing the line too close to their shores.

The technical difficulty of maintaining a continuous 24-hour watch on the line for a period of years.

Appendix 12-F presents the detailed costs of 3 system variations that do not have a non-contiguous early-information line.

We have concluded that the non-contiguous early-information line as costed represents only a small percentage of the total system cost. The line does provide a small increase in combat effectiveness based on a quantitative evaluation. This increase in effectiveness was only slightly less than that achieved by putting an equal amount of money into weapons for the contiguous zone. The qualitative advantages of the line outweigh the above small relative disadvantage in combat effectiveness and the Basic Lamp Light System was, therefore, designed with the early-information line.

1957 Variation

Section III discussed the desirability of examining the proposed 1960 air defense system at an intermediate time, such as 1957, to achieve maximum compatibility with the proposed Lamp Light system and the ADR 54-60 plan.

The time lag between an order for new or additional quantities of equipment and their operational date is such that it is virtually impossible to have any more equipment on hand in 1957 than is now planned by CONAD. Therefore, the philosophy in postulating a defense system for 1957 has been to use the same quantities of equipment as listed in the ADR 54-60 plan with one exception. The Navy has programed 12 YAGR picket ships to be operational by mid-1957. Since these are operated only a few hundred miles offshore, a very optimistic back-up factor of 2 will permit 6 picket ship stations. The ADR 54-60 plan lists 4 picket vessel stations. The only modification in deployment from that given by the ADR 54-60 plan is for those items that are mobile, such as picket ships and airborne radars. All land-based installations remain the same as the ADR 54-60 plan.

As discussed in Appendix 12-E, the system proposed for 1957 uses all the available picket ships and airborne radars in the Atlantic ocean area. Figure 12-13 shows the high-altitude coverage by the picket ships extending out approximately 750 miles. The AEW&C aircraft are used primarily for low-altitude surveillance and, because of radar clutter return, must fly at about 2500 feet. The line-of-sight on low-altitude targets is only 80 miles. With the programed force for 1957, and using a back-up factor

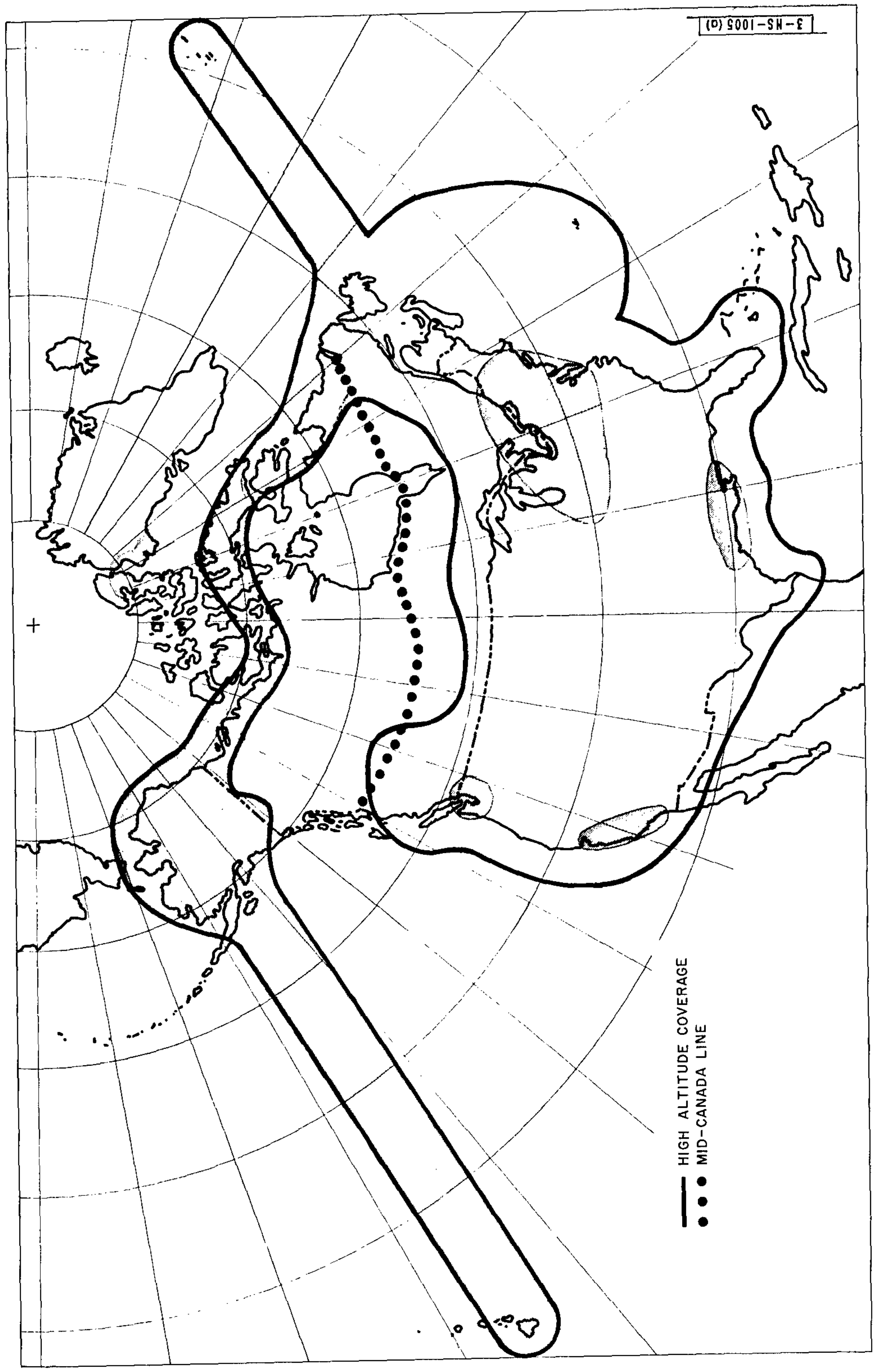


Fig. 12-13. Air defense data zone – 1957 variation.

of 5 to 1, solid low-altitude coverage extends only 200 to 250 miles out from shore.

Inadequacies in the proposed system for 1957 are quite apparent. The small number of airborne radars and picket vessels severely limits the offshore coverage in which adequate data for an air battle can be achieved. Also, only a small number of supersonic interceptors and guided missiles will be available. Beginning in 1957, the manual system for intercept control is to be replaced by SAGE.

Figure 12-13 also shows an early-information line extending from Hawaii to Alaska, over northern Canada, down the eastern coast to Newfoundland and out to the Azores. This is desirable to provide SAC and other agencies with enough early warning. It should be noted, however, that all agencies are trying to reduce the amount of early warning that they require.

Basic elements of this system, which is the same as ADR 54-60, can be improved and added to by the addition of new units as they become available to provide a gradual growth and transition to the system described in Sec. VI.

VIII. CONCLUSIONS

Although other aspects of the defense of North America remain to be discussed in Chapters 13 and 14, certain conclusions were evident as a result of the studies in the contiguous defense zone set forth in this chapter. These conclusions are listed below.

Establishment of a contiguous surveillance and tracking zone completely around the principal defended areas extending to a distance of 1400 miles for high-altitude targets and 1000 miles for low-altitude targets, accompanied by a contiguous combat zone extending out to 700 miles, is a definite technical possibility by 1960. Development of the capability to establish an extended contiguous defense zone, as described, appears desirable for the reasons listed in Sec. III.

The systems to combat air, surface and subsurface target threats in the contiguous ocean areas have many common requirements that need not be duplicated. The U.S. Navy can perform a vital role in air defense by incorporating certain functions and requirements into units carrying out other responsibilities in the sea areas.

Picket ships and aircraft used to extend contiguous cover to seaward must be equipped to:

Detect, identify, and control aircraft in the seaward approaches,

Detect, identify, and transmit surveillance data on surface ships and submarines.*

*The mission of AEW aircraft will not include the detection of submerged submarines.

These capabilities are needed in order to:

> Concentrate the job of countering the air, surface and submarine threats into the minimum number of weapons system.
>
> Provide a combat-control capability as insurance in case of loss of units of the SAGE System, and to allow combat control to extend beyond the coverage of the SAGE System.
>
> Allow maximum flexibility for cooperation with other units of the Navy, sea-surveillance systems, and NATO forces.
>
> Increase the difficulty of enemy planning for use of countermeasures.

Development of AEW and AEW&C aircraft systems of greatly improved performance by 1960 is both technically possible and urgently required. These improved airborne systems can provide 360° high-probability-of-detection coverage from the surface to 80,000 feet, ability to conduct limited combat control, and ability to operate effectively over rough seas. Depending on the outcome of urgently recommended clutter research over land and pack ice, it may also be feasible to extend operation to these areas.

The defenses will require additional capability against high-altitude targets between 60,000 and 80,000 feet by 1960. This is desirable in all combat zones. Use of high-altitude missiles, such as Bomarc and improved versions of Nike and Talos, could provide this at very short ranges. It is desirable to provide jump-up capability in air-to-air missiles to be launched from both medium- and long-range interceptors.

There is a need for a low-altitude capability and an anti-ASM capability in the short-range surface-to-air missiles (such as Nike and Talos) to improve kills in local defense area.

The outward extension of air defense operations over the ocean involves the participation of naval units in the air defense task. In Chapter 12, the problem has been developed in functional sequence, without particular attention to organizational questions. Since the role of naval units in air defense was one of the original questions leading to the formation of Project Lamp Light, it seemed worth while to assemble in a single section of our report all those aspects of the air defense problem that are of direct and primary interest to those concerned with naval operations; this has been done in Appendix 12-E.

The success of the contiguous defenses described in this chapter depends upon the development of a number of components not now available. Even though this particular defense system may not be implemented in exactly this way, these components will improve any defense system that seeks to strengthen by outward expansion, and they

should be obtained without delay. While these items have been suggested in earlier chapters of this report by the Components Groups, they need to be repeated and underlined from the Systems Group standpoint:

For Interceptors

The CW, pulse-Doppler and S-band AI radars as proposed by the radar group (Chapter 3).

The Ding Dong-type armament (Chapter 10).

Jammer homers for air-to-air missile armament (Chapters 9 and 10).

Infrared detectors for high-altitude detection, and infrared target seekers for missiles (Chapter 9).

Navigational computers to allow operations in the extended combat areas (Chapter 7).

Air-to-air missiles with "jump-up and jump-down" capability (Chapter 10).

Higher combat ceilings for interceptors using thrust augmentation (Chapter 10).

For AEW Aircraft

UHF and S-band radars with big antennae (30 × 8 feet) (Chapter 2).

Long-range height finders as proposed (Chapter 2).

AMTI equipment for these radars (Chapter 2).

Clutter research over land and arctic ice (Chapter 2).

Navigational computers for accurate navigation (Chapter 7).

For Picket Vessels

Phase 1 and Phase 2 data-processing systems and intercept-control computers as proposed by the Data Processing Group (Chapter 7).

For Short-Range Surface-to-Air Missiles

Low-altitude and anti-ASM capability (Chapter 10).

Jammer-homing capability (Chapter 9).

General

Improved and reliable IFF (Chapter 8).

Communication systems proposed for AEW and picket vessels (Chapter 6).

CHAPTER 12 RECOMMENDATIONS

1. *We recommend development of the capability to establish an extended contiguous defense zone.*

2. *We recommend that picket ships and aircraft used to extend contiguous cover to seaward be equipped to:*

   (a) *Detect, identify, and control aircraft in the seaward approaches.*

   (b) *Detect, identify, and transmit surveillance data on surface ships and submarines.*

3. *We recommend the development of AEW and AEW&C aircraft systems of greatly improved performance by 1960.*

4. *To provide additional capability, in the contiguous zone, against high-altitude targets between 60,000 and 80,000 feet by 1960, we recommend the use at very short ranges of high-altitude missiles. We also recommend providing jump-up capability in air-to-air missiles to be launched from both medium- and long-range interceptors.*

5. *To improve kills in local defense areas, we recommend research and development toward a low-altitude capability and an anti-ASM capability in our short range surface-to-air missiles.*

APPENDICES TO CHAPTER 12

APPENDIX 12-A
WEAPON CHARACTERISTICS AND SYSTEM PROBABILITIES FOR DEFENSE SYSTEMS

This appendix presents the characteristics and weapon system probabilities used in defining and evaluating the defense systems discussed in Chapter 12. The interceptor and missile characteristics for the 1957 and 1960 time periods have been based on Standard Aircraft Characteristics charts and weapon manufacturers' reports. These characteristics have been reviewed by qualified members of Lamp Light and are believed attainable by the time periods in question. It must be emphasized, however, that new equipments or advances in technology are required to achieve many of these characteristics. In some cases, the advances are not called for in the above information sources. A few of these advances that have been recommended elsewhere in this report are:

> Improved AI radars, especially at low altitude (C, W or pulse Doppler, or larger radar antennas at S-band);
>
> Improved interceptor combat altitudes through thrust augmentation and/or air-to-air missile "fly-up" capability;
>
> Terminal homing seekers for the Nike B surface-to-air missiles required to achieve a low-altitude capability;
>
> Improved acquisition radars for surface-to-air missiles in order to detect small, high-speed, high-altitude air-to-surface missiles.

The weapon system probabilities have been based on available information and as a result of much discussion on the part of Lamp Light personnel. While the absolute values of these probabilities are subject to large uncertainties, it is believed that the relative values between the several different weapon types are reasonably valid.

Also, it must not be inferred that the weapons used in the systems of Chapter 12 are the only weapons that can or should be used. They are, however, representative weapons that have been programed or seriously considered for air defense use and for which development and testing is well under way.

The summary characteristics and probabilities of the 1957 interceptor system, the 1960 interceptor system and the surface-to-air missile system are summarized in Tables 12A-I through 12A-VI.

C.M. Forsyth
L.K. Edwards

TABLE 12A-1

1957 INTERCEPTOR SYSTEM SUMMARY CHARACTERISTICS

Types	Operational Combat Radius (n.mi.)	Operational Combat Altitude (ft)	Cruise Speed (kts/ft alt.)	Combat Speed (kts/ft alt.)	Time and Distance (2) to 40,000 (min/n.mi.)	Radar Fire-Control System	Armament Complement
1. MRI a. F-102A (J-57 engine)	425(1)	55,600	510/45,000 with cruise power 620/5,000 with mil. power	650/5000 680/15,000 760/35,000 610/45,000 530/55,000	5.5/40 @ Max. Power	MG-3 with a 22-inch dia. dish	6 GAR-1 or 1B missiles and 48-2 inch FFAR
2. SRI a. F-86-D	170(1) no external fuel 280 with external fuel	52,000	470/41,000 with cruise power 575/5000 with mil. power	600/5000 590/15,000 540/35,000 530/45,000 520/50,000	8/60 @ Max. Power	MG-3 with a 22-inch dia. dish	48 2-inch FFAR
3. MRI (Canadian)	425(1)	46,000	440/35,000 with cruise power 510/5000 with mil. power	545/5000 530/15,000 490/35,000 440/45,000	14/90 @ Mil. Power	MG-2 with a 22-inch dia. dish	4 20-mm T-160 guns and 90 2-inch FFAR
Armament	Range (n.mi.)	Operational Altitude (ft)	Time of Flight	Final Velocity			Warhead and Fuze
4. AAM a. Falcon GAR-1 or 1B	1 to 4	5000 to 55,000	$t_f \simeq$ 10 sec for 4 n. mi.	M = 2.5			8# blast, contact fuze
5. AAR a. 2.00 inches	0.5	Sea level to 60,000	a/g = 90 (acceleration) t_f = 1.25 sec	Burnt Velocity is 32,000 fps from a M = 1.0 launch			1.4# blast, contact fuze

(1) The operational combdt radius is 15% less than the MIL-C-5011a spec. area intercept mission radius to allow from 8 to 15 minutes combat at 50,000 feet (5 minutes per MIL-C-5011a) or combat at lower altitudes

(2) The time and distance to 40,000 feet is from brake release

TABLE 12A-II

1957 INTERCEPTOR SYSTEM PROBABILITIES

Type	Probability of Reaching Combat Area, P_i (1)	Average Radar Detection Range for 0.9 Probability (n.mi.)	High-Altitude Probability of AI Detection and Conversion, P_d TU-4	Type 37	P_k per firing pass	Interceptor Probability of Survival, P_s	Probability of Detecting and Converting on a Target for a Second Pass (Mass Raid), P_{ra}	Expected kills per Interceptor (3) TU-4	Type 37
1. MRI a. F-102A	0.85 High Alt. 0.80 Low Alt.	20 High Alt. 2 Low Alt.	0.90 High Alt. 0.50 Low Alt.	0.85 High Alt. 0.25 Low Alt.	0.6 for each of two passes at High Alt. 0.4 for one pass at Low Alt.(2)	1.00 High Alt. 0.95 Low Alt.	0.65 High Alt. –	0.76 High Alt. 0.15 Low Alt.	0.72 High Alt. 0.08 Low Alt.
2. SRI a. F-86D	0.85 High Alt. 0.80 Low Alt.	20 High Alt. 2 Low Alt.	0.90 High Alt. 0.50 Low Alt.	0.50 High Alt. 0.20 Low Alt.	0.3 for one pass at High Alt. 0.4 for one pass at Low Alt.(2)	1.00 High Alt. 0.95 Low Alt.	– –	0.23 High Alt. 0.15 Low Alt.	0.13 High Alt. 0.06 Low Alt.
3. MRI (Canadian) a. CF-100	0.85 High Alt. 0.80 Low Alt.	20 High Alt. 2 Low Alt.	0.90 High Alt. 0.50 Low Alt.	0.50 High Alt. 0.20 Low Alt.	0.3 for each of two passes 0.4 for each of two passes	1.00 High Alt. 0.95 Low Alt.	0.60 High Alt. 0.4 Low Alt.	0.37 High Alt. 0.21 Low Alt.	0.02 High Alt. 0.09 Low Alt.

(1) Includes mechanical failures and gross vectoring errors

(2) Only the 2-inch rockets and guns are usable at very low altitudes. P_k is higher for the rockets at low altitude than at high altitude because of increased blast damages and the smaller fire control errors for tail attacks

(3) Expected kills per interceptor = $P_i \times P_d \times P_s [P_{k_1} + P_{ra} P_{k_z} + P_{ra}^2 P_{k_3} \ldots]$

TABLE 12A-III

1960 INTERCEPTOR SYSTEM SUMMARY CHARACTERISTICS

Types	Operational Combat Radius (n.mi.)	Operational Combat Altitude (ft)	Cruise (kts/ft alt.)	Combat Speed (kts/ft alt.)	Time and Distance to 40,000 (min/n.mi.)	Radar Fire Control System	Armament Complement
1. MLRI a. IF-101B (two J-67 or J-75 engines)	700(1)	55,000	500/40,000 with cruise power 650/5000 with mil. power	850/5000 1000/15,000 1140/35,000 1120/45,000 1030/55,000	2.5/20 @ Max. Power	40-inch dia. dish at S-band	6 GAR-1A and 100 2" FFAR or 3 Ding Dong and 50 2" FFAR
2. MRI a. F-102B (one J-67 engine)	300(1)	58,000	510/45,000 with cruise power 630/5000 with mil. power	850/5000 980/15,000 1200/35,000 1150/45,000 800/55,000	3.0/25 @ Max. Power	Spaced-active CW (3 antennas) or Pulse Doppler	6 GAR-1A and 48 2" FFAR or 3 Ding Dong
b. CF-105 (two J-67 engines)	460(1)	59,000	540/40,000 650/5000 with mil. power	770/5000 980/15,000 1200/35,000 1200/45,000 1100/55,000	2.5/20 @ Max. Power	Spaced-active CW (3 antennas) or Pulse Doppler	3 Sparrow III or 8 GAR-1A
Armament	**Range (n.mi.)**	**Operational Altitude (ft)**	**Time of Flight**	**Final Velocity**			**Warhead and Fuze**
3. AAM a. Falcon GAR-1A	1 to 4	5000 to 65,000	$t_f \simeq 10$ sec for 4 n. mi.	M = 2.5			12# blast, contact fuze
b. Sparrow III	3 to 6	Sea Level to 70,000	$t_f \simeq 10$-20 sec	M = 2.0 to 2.5			40# HBX 22# Fragments, Proximity fuze
4. AAR a. 2.00 inches	0.5 range	Sea Level to 60,000	a/g = 90 (acceleration) $t_f = 1.25$ sec	Burnt Velocity is 3200 fps from a M = 1.0 launch			1.4# blast, contact fuze
5. Ding Dong	3 to 4	Sea Level to 65,000	$t_f = 3$-7 sec	Final Velocity 4000 fps from a M = 1.0 launch			Special warhead

(1) The operational combat radius is 15% less than the MIL-C-5011a spec. area intercept mission radius to allow from 8 to 15 minutes combat at 50,000 feet (5 minutes per MIL-C-5011a) or combat at lower altitudes

(2) The time and distance to 40,000 feet is from brake release

TABLE 12A-IV

1960 INTERCEPTOR SYSTEM PROBABILITIES

Type	Armament	Probability of Reaching Combat Area, P_i (1)	Average Radar Detection Range for 0.9 Probability (n.mi.)	High-Altitude Probability of AI Detection and Conversion, P_d Type 37	P_k per firing pass	Interceptor Probability of Survival, P_s	Probability of Acquiring a Target for a Second Pass (Mass Raid), P_{ra}	Expected kills per Interceptor (2) Type 37
1. MLRI a. IF-101B	3 Ding-Dongs plus 50 2-inch FFAR	0.85 High Alt. 0.85 Low Alt.	35	0.90 High Alt. 0.70 Low Alt.	0.9 for each of three passes, 0.6 for fourth pass	1.00	0.75 High Alt. 0.60 Low Alt.	1.76 High Alt. 1.12 Low Alt.
2. MRI a. F-102B	3 Ding-Dongs	0.90 High Alt. 0.85 Low Alt.	20	0.85 High Alt. 0.65 Low Alt.(3)	0.9 for each of three passes	1.00	0.65 High Alt. 0.30 Low Alt.(3)	1.43 High Alt. 0.70 Low Alt.
3. MRI (Canadian) a. CF-105	3 Sparrow III	0.90 High Alt. 0.85 Low Alt.	20	0.85 High Alt. 0.65 Low Alt.(3)	0.6 for each of three passes	1.00	0.65 High Alt. –30 Low Alt.(3)	0.97 High Alt. 0.47 Low Alt.

(1) *Includes mechanical failures and gross vectoring errors*

(2) Expected kills per interceptor = $P_i \times P_d \times P_s \, [P_{k_1} + P_{ra} P_{k_2} + P_{ra}^2 P_{k_3} + P_{ra}^3 P_{k_4}]$

(3) *The CW or pulse Doppler radar used in the MRI restricts attacks to the forward hemisphere only.* In addition, the detection range is lower than that for the MLRI due to the smaller radar antenna; therefore, lower probabilities have been estimated for the P_d and P_{ra} of the MRI's

TABLE 12A-V

SUMMARY CHARACTERISTICS OF SURFACE-TO-AIR MISSILE SYSTEMS

Weapon	Warhead	Guidance	High-Altitude Targets		Guidance Limit on Rate of Fire
			Max. Range† (n.mi.)	Max. Altitude (ft)	
Nike I (1957 availability)	HE (300#)	Command	25	60,000	Each battery controls 1 missile at a time
Nike B (1960 availability)	HE (1200#)	Command plus seeker	50	80,000	Each battery controls 2 missiles simultaneously
Nike B* (1960 availability)	Special	Command plus seeker	50	80,000	Each battery controls 2 missiles simultaneously
Talos L (1960 availability)	HE (420#)	Beam rider plus seeker	80	70,000	Each battery controls up to 6 salvos (12 missiles) simultaneously
Talos LW (1960 availability)	Special	Beam rider only	80	70,000	Each battery controls up to 6 missiles simultaneously

†The maximum range at which low-altitude targets can be engaged is about one-half the high-altitude range

TABLE 12A-VI

SUMMARY CAPABILITIES OF SURFACE-TO-AIR MISSILE SYSTEMS

Target	Missile	Probability of Ground System Being Able to Launch and Guide a Missile Satisfactorily	Probability of Missile Accomplishing a Kill If Ground System Operates	Over-all Kill Probability per Missile	Maximum Effective Range of Missile (n.mi.)	Maximum Fire Capability
Subsonic Bombers and Decoys	Nike I	0.9	0.33	0.30	See Table 12A-V	See Table 12A-V
	Nike B	0.9	0.55	0.50	See Table 12A-V	See Table 12A-V
	Nike B*	0.9	0.8	0.72	See Table 12A-V	See Table 12A-V
	Talos L	0.9	0.55	0.50	See Table 12A-V	See Table 12A-V
	Talos LW	0.9	0.8	0.72	See Table 12A-V	See Table 12A-V
Supersonic Air-to-Surface Missiles†	Nike I	–	–	–	–	–
	Nike B	0.9	0.3	0.27	20	2 missiles per battery per ASM
	Nike B*	0.9	0.8	0.72	20	2 missiles per battery per ASM
	Talos L	0.9	0.3	0.27	20	2 missiles per battery per ASM
	Talos LW	0.9	0.8	0.72	20	2 missiles per battery per ASM

†Capabilities against supersonic air-to-surface missiles apply only if missiles can be detected at ranges of the order of 60 miles and at their cruising altitude, which is unlikely unless great improvement is made in the missile system acquisition radars.

APPENDIX 12-B

NORTHWARD EXTENSION OF LAND-BASED CONTIGUOUS RADAR COVERAGE

PRIME RADARS

The high-altitude, contiguous radar coverage over Canada can be extended by adding additional prime radars. The coverage is extended northward to the distances specified in Chapter 12 by the addition of 10 prime radars of the Sentinel type as discussed in Chapter 4. These radars are expected to have a 240-mile detection range.

Figure 12B-1 shows the north edge of the contiguous coverage of the ADR 54-60 plan and the additional coverage given by the 10 radars located at Knob Lake, Great Whale River, Weenusk, Flin Flon, Port Harrison, Churchill, Coral Harbor, Goldfield, Fort Nelson and Petersburg.

GAP FILLERS

The density of gap-filler radars in Canada for low-altitude cover around the heartland is dependent on the roughness of the terrain and the extent to which high sites can be utilized. The FPS-14 (or equivalent) radar, which has a detection range of about 32 miles, is used. The ADR 54-60 plan calls for low-altitude coverage around the heartland up to about the 50th parallel, as shown in Fig. 12B-2. In this area there are sufficient railroads, highways, lumber roads and forest roads, that there is little difficulty in establishing gap-filler sites.

The extension of the low-altitude coverage out to about 600 miles in Ontario and Quebec requires an additional 75 gap-filler radars. These sites are more difficult to reach than those below the 50th parallel and, except for about 15 sites in the James Bay region, will require either cat-train or air-lift transportation. As shown in Fig. 12B-2, these radars will extend the solid coverage up to a line running from Winnipeg to the mid-Canada line at James Bay, along the mid-Canada line to Knob Lake, and then south to the St. Lawrence River.

T.P. Higgins, Jr.

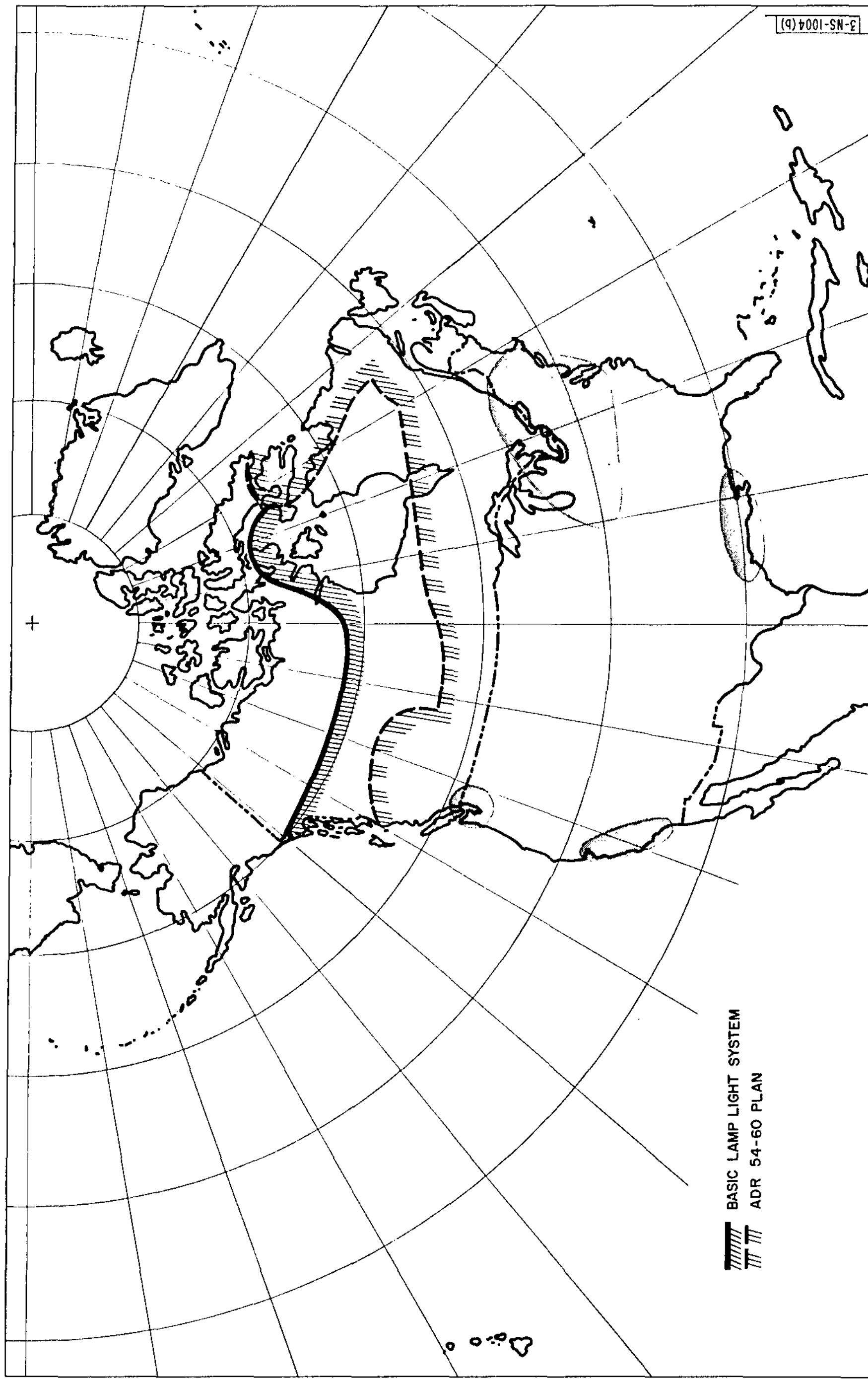


Fig. 12B-1. Northward extension of high-altitude contiguous radar coverage over land.

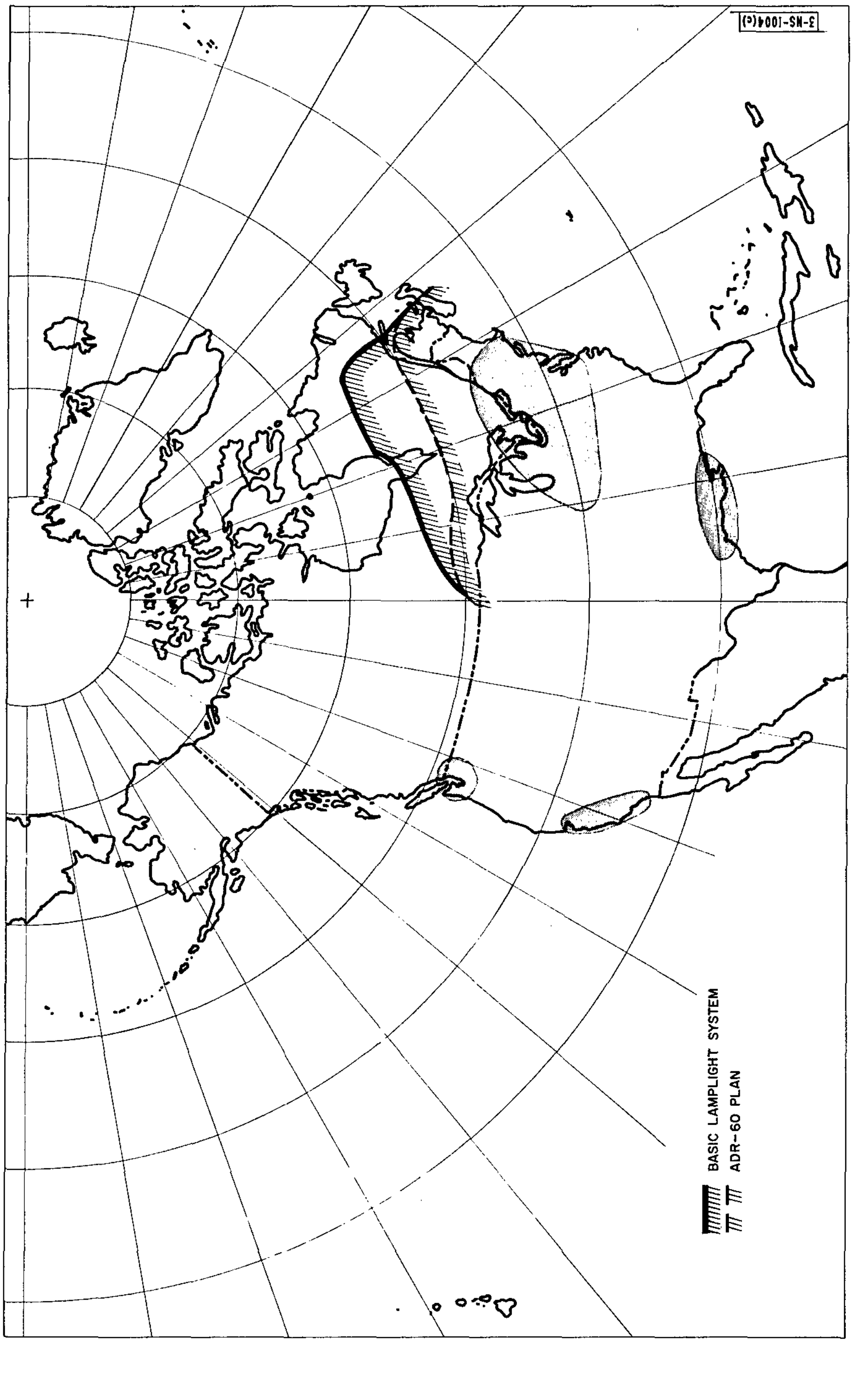


Fig. 12B-2. Northward extension of low-altitude contiguous radar coverage over land.

APPENDIX 12-C
EXTENSION OF CONTIGUOUS COVERAGE OVER THE OCEAN

GENERAL

The general characteristics of the picket ships and airborne radars and how they provide air surveillance and weapon control were discussed in Chapter 12. The desirability of extending the contiguous radar coverage over the ocean areas was also indicated.

ATLANTIC OCEAN

Over the Atlantic ocean, the airborne radars are used to provide high- and low-altitude coverage out to 1000 miles (approximately) from shore as shown in Fig. 12C-1. Aircraft operating from bases in the vicinity of Boston, Norfolk and Jacksonville, and flying 2300-mile round-trip patterns, can provide the desired coverage. With an aircraft spacing of 300 miles, and using a 5-to-1 back-up factor (144 hours-per-month utilization), 115 aircraft are required.

As can be seen in Fig. 12C-1, there are 3 rows of picket ships. Although the 2 rows nearest the shore provide redundant high-altitude coverage, the primary purpose of the pickets is to serve as data-processing centers and provide intercept control. The first row of pickets is about 350 miles offshore; the second row, about 700 miles. Spacing between the pickets along each row is 250 to 300 miles. Note that Bermuda and a West Indies island east of Florida are used to minimize the number of pickets required.

The third row, which includes 3 weather ships with the 7 pickets, is the outer perimeter of radars which provide only solid high-altitude coverage. Since these pickets are beyond the combat zone, it is not necessary that they have intercept computers with their data-processing equipment.

PACIFIC OCEAN

Surveillance and weapon-control units over the Pacific are the same as those over the Atlantic. Fig. 12C-1 shows airborne radars operating from bases in the vicinity of Seattle, San Francisco and San Diego. Each round-trip pattern is about 1800 miles long and provides high- and low-altitude surveillance out to approximately 700 miles. A total of 90 aircraft is required.

Only one row of 5 picket ships is used; these are located about 300 miles offshore. These ships have intercept-control computers in the data-processing equipment.

T.P. Higgins, Jr.

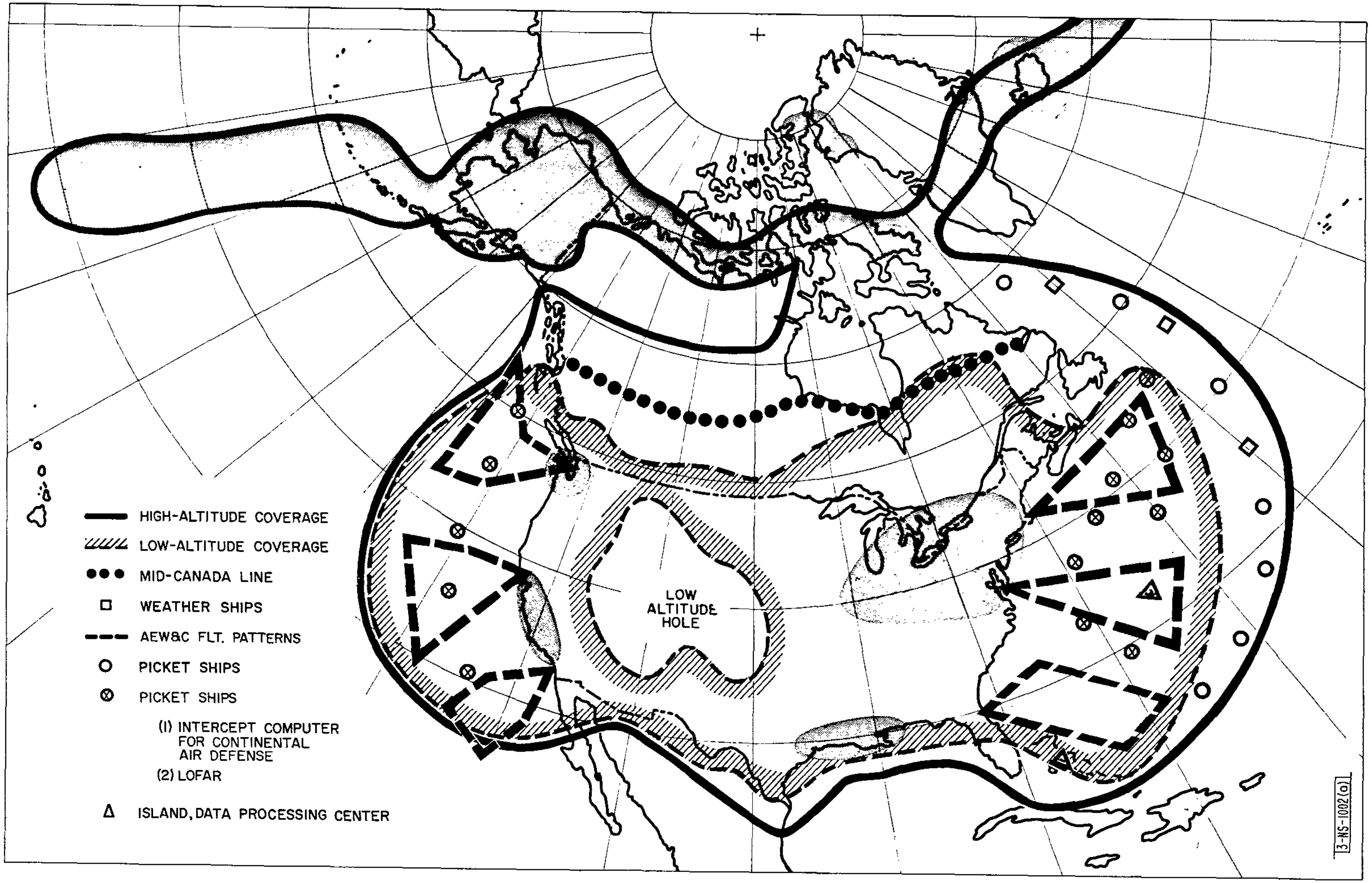


Fig. 12C-1. Contiguous radar coverage over the oceans — 1960 Basic Lamp Light System.

APPENDIX 12-D

WEAPON DEPLOYMENT FOR 1960 BASIC LAMP LIGHT SYSTEM

The weapon deployment for the 1960 time period is given in this Appendix. As mentioned in Chapter 12, the 1957 weapon deployment is the same as that specified in the ADR 54-60 plan. The NEAC, ALAC and augmentation fighters for both 1957 and 1960 are also deployed in accordance with ADR 54-60.

The deployment for the 1960 time period is based upon the theory of placing interceptors close to the area to be defended in order to minimize the numbers required in providing "all-around" defense. Approximately 70 per cent of the weapon strength is in or near the heartland.

The only air bases that have been used are those discussed in the ADR 54-60 plan. These bases are now in use or will soon be available for fighter-type operations.

The local surface-to-air missiles have also been deployed in general accordance with the ADR 54-60 plan. Of the 25 additional battalions over the ADR 54-60 plan, 17 have been placed in the heartland.

Medium Long-Range Interceptors (F-101B), 50 Squadrons

Location	No. Squadrons
Presque Isle, Me.	3
Burlington, Vt.	4
Otis AFB, Mass.	4
McGuire AFB, N.J.	4
Langley AFB, Va.	3
Niagara Falls, N.Y.	4
Kinross AFB, Sault Sainte Marie, Mich.	4
Duluth, Minn.	3
Minot Airport, N.D.	3
Great Falls AFB, Mont.	2
Geiger AFB, Spokane, Wash.	2
Kirtland AFB, Albuquerque, N.M.	2
Pittsburgh, Pa.	2
Scott AFB, Ill.	2
Patterson AFB, Dayton, Ohio	2
Dover, Del.	2
Albany, N.Y.	2
Syracuse, N.Y.	2

Medium-Range Interceptors (F-102B), 100 Squadrons

Location	No. Squadrons
Hamilton AFB, Calif.	2
Portsmouth, N.H.	4

Location	No. Squadrons
Newburgh, N.Y.	4
Hanscom AFB, Bedford, Mass.	2
New Castle, Del.	4
Westover AFB, Mass.	3
Griffiss AFB, Rome, N.Y.	2
Andrews AFB, Md.	3
Richmond, Va.	2
Suffolk Co., Long Island, N.Y.	4
Millville, N.J.	4
Salisbury, Md.	3
Seymour-Johnson AFB, N.C.	2
Knoxville, Tenn.	2
Charleston, S.C.	2
Youngstown, Ohio	3
Columbus, Ohio	3
Wurtsmith AFB, Oscoda, Mich.	4
Bunker Hill AFB, Peru, Ind.	3
Traverse City, Mich.	3
Moline, Ill.	2
Chicago, Ill.	3
Madison, Wis.	3
Marquette, Mich.	3
Minneapolis, Minn.	2
Larson AFB, Moses Lake, Wash.	2
Paine AFB, Everett, Wash.	2
Portland, Ore.	2
Travis AFB, Fairfield, Calif.	2
Castle AFB, Merced, Calif.	2
Mather AFB, Sacramento, Calif.	2
Oxnard AFB, Calif.	2
Edwards AFB, Calif.	2
Camp Pendleton, Calif.	3
New Orleans, La.	2
Selfridge AFB, Mich.	3
Fort Worth, Texas	2
Barksdale AFB, La.	2

Medium-Range Canadian Interceptors (CF-105), 10 Squadrons

Location	No. Squadrons
Edmonton	1
Regina	1
Winnipeg	1
Ottawa	2
Montreal	2
Quebec	2
Vancouver	1

Local Surface-to Air Missiles (Nike B), 125 Battalions

Location	No. Battalions (Dual)
New York, N.Y.	14
Washington-Baltimore	8
Chicago, Ill.	8
Los Angeles, Calif.	5
Detroit, Mich.	7
Philadelphia, Pa.	6
Buffalo, N.Y.	4
Pittsburgh, Pa.	3
San Francisco, Calif.	3
Boston, Mass.	4
Seattle, Wash.	3
Norfolk, Va.	2
Hanford, Wash.	1
Cleveland, Ohio	3
Milwaukee, Wis.	3
Bridgeport, Conn.	1
Providence, R.I.	2
Hartford, Conn.	1
Limestone, Me.	1
Castle AFB, Calif.	1
Westover AFB, Mass.	1
Fairchild AFB, Wash.	1
Travis AFB, Calif.	1
March AFB, Calif.	1
Ellsworth AFB, S.D.	1
Carswell AFB, Texas	2
Dow AFB, Me.	1
Portsmouth, N.H.	1
Syracuse, N.Y.	2
Flint, Mich.	2
Portland, Ore.	1
South Bend, Ind.	2
Toledo, Ohio	2
San Diego, Calif.	2
Sault Sainte Marie, Mich.	1
Erie, Pa.	1
Albany, N.Y.	1
Grand Rapids, Mich.	2
Utica, N.Y.	1
St. Louis, Mo.	2
Youngstown, Ohio	2
Minneapolis, Minn.	2
Savannah River, S.C.	1
Rochester, N.Y.	2
Kansas City, Mo.	2
Montreal	2
Ottawa	1
Toronto	2
Quebec	2
Vancouver	1

C. M. Forsyth

APPENDIX 12-E

THE NAVY'S OPERATIONAL ROLE IN CONTINENTAL DEFENSE

This appendix deals with the continental United States defense problems in the sea approaches to the North American continent and pays particular attention to its air defense aspect. The details of the considerations relative to the surface and subsurface threat are treated in Chap. 14.

We acquainted ourselves, in a limited way, with the defense responsibilities that have been given to the three Joint Chiefs of Staff commanders who are primarily interested in defense of the U.S. in the offshore ocean areas. These we understand to be the Commander-in-Chief, Continental Air Defense Command; Commander-in-Chief, Atlantic; and Commander-in-Chief, Pacific. Without attempting, or presuming, to explore operational policies or problems in detail, it appeared to us that the major deficiency that now exists in the ocean areas is the absence of a system for collecting, processing and using surveillance and tracking data. As we saw the problem, it was obvious that for any one of three interested commanders to be able to discharge his defense responsibilities, it would be necessary for him to have available, rapidly and reliably, a detailed appreciation of enemy vehicles penetrating toward the coasts, starting far enough to seaward to allow him to make appropriate decisions regarding defense force commitments. The end goal was to provide each commander with a means for taking positive and effective counteraction against approaching enemy vehicles before they could reach bomb-release points or weapon-launching positions. We felt that such a surveillance and tracking system would draw important support from barrier lines, that is, distant information lines, positioned for effectiveness against aircraft and submarines departing from Soviet territory. In addition, the system would draw support from general surveillance achieved through random U.S. and allied shipping that exists in the mid-ocean areas, as described in Chap. 13. However, the solid surveillance and tracking system that is necessary in the offshore areas would not be dependent upon such support.

Our underlying philosophy, then, toward the sea approaches to the United States, where technical difficulties are more severe than on land, was that a system should and could be put in place, which would provide, out to hundreds of miles, a continuous surveillance and tracking capability against air, surface and subsurface threats. This system would also have inherent in it a capability for rapidly generating combat data, for example, intercept vectors, which could be used by defense weapons that the operational commanders might decide to commit to the areas.

With the foregoing points in mind, and based upon the technical means in the fields of communications, detection, and data processing that have been presented, we are able to describe a representative system that would, as a start, employ forces already programed by the Navy and which would meet certain basic objectives that can be stated for such a system. Some of these objectives have already been mentioned in Chap. 12; they are re-emphasized below, and further objectives have been added.

> To achieve by 1960, through existing technologies and techniques developed within Project Lamp Light, a better defense of North America against attacks that might develop through the Atlantic and Pacific Ocean approaches.
>
> To insure that the system suggested is compatible, technically and operationally, with the SAGE System now programed for continental air defense.
>
> To insure that, in the sea approaches, maximum economy of force, including personnel, is achieved for any given level of defense capability desired, and further, that the system is designed to handle data associated with the air threat, the surface threat and the subsurface threat.
>
> To insure that the electronic environment, particularly in the field of communications, suggested for the sea approaches is compatible with the more mobile forces of the Navy which may be operating from time to time in the area.
>
> To insure that the system suggested is one that lends itself toward an ideal level as forces, personnel and funds become available to the military departments and, as a corollary, that the system does not depend upon 100 per cent implementation for providing a degree of effectiveness.
>
> To insure that the sea system, if implemented to the ideal level, provides a means for military commanders to conduct effective combat in defense of the U.S. in the offshore areas against enemy vehicles of destruction. More specifically, to provide a continuous surveillance and tracking capability with inherent capacity for generating data necessary for combat in the following categories:
>
> > Air Targets:– Against high-flying aircraft in the Atlantic out to 1400 miles from heartland target complex,
> >
> > Against low-flying aircraft in the Atlantic out to 1000 miles from the critical heartland area,
> >
> > Against high- and low-flying aircraft in the Pacific in an area between San Diego and Seattle to seaward 700 miles,
> >
> > Surface and Subsurface Targets:– In the Atlantic, inside a line from Argentia to Bermuda to Puerto Rico,
> >
> > In the Pacific, inside an area between San Diego and Seattle to seaward 600 miles.

In meeting these objectives our feeling was that the first and, indeed, the greatest effort in the sea areas should be applied in the Atlantic Ocean, in view of its proximity to the heartland of the U.S. and Canada. In addition, we felt that, if all the objectives were to be met by 1960, it would be necessary to start putting in place components of the ultimate system by 1957 in order to gain operational experience and provide for logical growth and refinement. Therefore, we examined the plans of the U.S. Navy as related to continental air defense forces and learned that for 1957 there are programed 12 YAGR type ships, and that by 1958 this number will have increased to 16 for use in the immediate offshore environment of the SAGE System – an area that has been termed the contiguous cover zone. These ships are planned as conversions of Liberty hulls, and there is some question as to the suitability for the purposes envisioned by Lamp Light. It is clear that a YAGR is a type of ship and does not have to be a Liberty hull. The programed YAGR ships are now planned for use in both the Atlantic and Pacific with roughly half of the total number in each ocean. Since the Lamp Light approach has been to place emphasis first in the Atlantic, our system uses all of the currently programmed YAGR ships, as they become available, in the Atlantic and locates nine of them continuously at sea in 1957. In Fig. 12C-1, the heavy line off of the east coast is about 750 miles to sea. Utilizing the kind of picket ship radar that was described in Chap. 4, it would be possible to equip each of the 9 stations with equipment possessing good line-of-sight detection capabilities out to 200 miles. The proposal for picket ships included two air-search radars, one of which would be a stacked-beam search and height-finding radar. In addition, a separate nodding-beam height-finding radar was suggested. Thus there would be two sources of air-search data and two sources of height data in these ships; if properly located within this area, they would provide high-altitude coverage for all the approximately one million square miles involved. It is our recommendation, also, that each of these ships should be equipped with the Phase I data-processing system (outlined in Chap. 7) with RATT circuits for exchanging data between the pickets and for delivering data to, or receiving it from, shore installations. An improved means of underwater surveillance (discussed in Chap. 14) should be developed and installed in these vessels by 1958 in order to support and augment the Lofar installation ashore in the field of antisubmarine warfare. We feel, also, that the possibilities of operating a helicopter from these ships should be investigated by the Navy to provide them with the versatile capabilities possessed by a rotary wing aircraft in ASW. In addition, we believe that the Navy should investigate the future possibilities of equipping each of these ships with a surface-to-air missile capability, such as Talos, to be used against any hostile aircraft that may come within their range.

For the 1957-58 period, the establishment of 9 picket stations in the area shown will provide a surveillance and tracking capability against high-flying aircraft out to about 750 miles from the perimeter of the heartland. It should be noted that this surveillance system would overlap that of the SAGE System as it will be achieved with presently installed shore-based radars augmented by Texas Tower type of equipment or the RC-121D type of AEW&C aircraft in a band from 200 to 250 miles offshore. The data output of the Phase I data system is compatible with and acceptable to the SAGE System.

In order to provide coverage against low-flying aircraft out to 1000 miles and to keep track of surface contacts in sea approaches, it will be necessary to employ airborne radars which will contribute information to the data-processing equipment installed in the YAGR ships. This should be done by 1960 and could be accomplished by that year if three separate patterns of flight from the East Coast of the U.S. to seaward were established as shown on Fig. 12C-1. Each pattern is about 2300 miles in length and seven continuously airborne radars flying at 20,000 feet are required in each pattern to fill in the coverage. This is predicated upon the assumption that by 1960 it should be possible to have available a new type of airborne radar, such as the equipment described in Chap. 2, with built-in height-finding capability, which will have a high probability of detection and will provide high resolution data out to 180 miles. The flight patterns depicted could employ some new version of the Naval WV-2 aircraft with this kind of radar. These aircraft would have a limited control capability, as well as the means outlined in Chap. 7 for transmitting data to the nearest picket ship for further processing.

Although penalized by its inability to fly at high altitudes, and by limited all-weather capabilities, an airship such as the Navy ZPN equipped with a high performance radar would seem to offer some interesting possibilities in our system. It is possible that the lower operating costs and low back-up factor involved in keeping one airship airborne may outweigh the fact that more airships would be required in any of these patterns to achieve the coverage required.

Figure 12C-1 shows that, aside from the introduction of the airborne patterns by 1960, we have increased the number of picket-ship stations from 9 to 16 and have brought three of the U.S. operated Atlantic weather stations into conjunction with the new line of picket ships. A minor adjustment of stations from those normally occupied is involved (on the order of 50 to 100 miles). For the northernmost picket station in the Davis Straits, there is serious question as to whether sea, wind and ice conditions experienced during winter would permit year-round manning.

Our feeling is that this new line of picket ships, including the weather ships, need not necessarily have the data-processing equipment that the other pickets should have. However, they should be equipped with the high-performance radar mentioned previously. This outboard line of picket ships should be considered as the perimeter radars in meeting our objective of establishing a surveillance zone 1400 miles out from the heartland against high-flying aircraft, and the data they acquire should be given, for processing, to the nearest inboard YAGR in the system.

We do propose that by 1960 the original 9 picket stations of this system should be equipped with the Phase II data-processing equipment. This is a semiautomatic system with a good capacity for handling air, surface and subsurface data. It is important to point out that in the sea system it is considered very desirable to eliminate operators from the system where such operators are likely to introduce errors or time delays. It is felt that men should be retained in the system where they can make decisions such as a determination of what information should be passed to adjacent stations or to shore installations. This, of course, means that we do not consider complete automaticity of the sea system either necessary or economic. Again, in 1960, the data output of this system is compatible with and acceptable to the SAGE System.

We believe that the arrangement in the Atlantic of airborne and shipborne radars, with a programed approach toward procuring better supporting equipment will provide a means for meeting the objectives in that area that we set for ourselves. We are aware that ultimate forces required for this purpose, and the personnel to operate them, are above those that the Navy now has in its tentative program. If by 1960 there is a more remote distant early information line in place, such as the land-based line across the Greenland Ice Cap, it might be possible to use the WV-2 aircraft now programed by the Navy for the barrier line between Argentia and the Azores in the solid surveillance and tracking system that has been described. At any rate, this system in the Atlantic would require, by 1960, total forces as follows to carry out 24-hour continuous operation.

> 32 ships, 2 ships/station. This back-up factor is based upon most optimistic estimates and, when operational experience is gained, may have to be scaled up to 2-1/2 ships per station.
>
> 105 WV-2, 5 aircraft/one airborne.

If funds and personnel were not available for implementing this system completely, we believe it reasonable to say that any portion of it could be put in place (for example,

the more northern ships and a single pattern of airborne radars) and still achieve a positive return in terms of improved defense. This means that the total system could be put in place by increments, starting most logically from north to south as funds, forces and personnel were made available for the purpose.

Project Lamp Light is aware that current Navy force levels and the operational commitments that the Navy has throughout the world impose limitations on what can be done now to contribute importantly to continental defense. This problem became quite apparent as we studied the benefits that would accrue to defense of the U.S. if carrier-based aircraft could be made available, on a continuous basis, in the offshore surveillance and tracking environment. For example, if there were always available in the offshore region two CVS-type aircraft carriers with fighter aircraft embarked, as well as one squadron, perhaps, of ASW aircraft, the Commander-in-Chief, Atlantic, would have the bare essentials of a weapon system to take advantage of the data provided by the electronic environment. We know, however, that the aircraft carriers of the Atlantic Fleet have a wide range of commitments which preclude any such employment on a continuing basis. It has been obvious, nevertheless, that if Navy force levels in the Atlantic, particularly as regards CVS-type aircraft carriers, were raised, very real benefits in <u>starting</u> attrition against inbound hostile aircraft and submarines would accrue. Such carrier-based aircraft available in the perimeter of the surveillance and tracking system could make earlier intercepts against bombers than will be possible in the case of continental U.S. based fighters. This does not suggest that the Navy could or should fight the total air battle in the Atlantic approaches to the U.S., but if there were such aircraft, possibly operated in conjunction with the present carrier ASW hunter-killer force in the Atlantic, the Commander-in-Chief, Atlantic could make important contributions to air defense of the U.S. It is our understanding that to keep one aircraft carrier at sea requires approximately 2-1/2 carriers and that, when one speaks of higher force levels for defense tasks this point must be kept in mind. We understand, however, that carrier hulls now in moth-balls could be rehabilitated and employed by 1960 for such purposes.

We believe also, that the carrier striking forces that form a part of the U.S. Atlantic Fleet can play important roles in defense of the U.S. prior to D-day. This seems particularly true during periods of alert that might be created as a result of strategic intelligence on Russian intentions that may be obtained in advance of actual overt acts. Therefore, it is entirely probable that these striking forces could be operating in or near the surveillance system in the Atlantic sea approaches during such periods. For

this reason the electronic characteristics of the system at sea should be functionally interchangeable with that of the striking forces of the Navy. However, the availability of carrier-based fighters of the Navy striking forces for static defense roles has to be viewed, generally, as transient and it must be understood they will not be available on a continuing basis after D-day.

Let us turn our attention now to the Pacific. Members of Project Lamp Light who have worked on system possibilities believe that the sea approaches in this ocean should receive attention as soon as possible after the Atlantic. By the year 1960, we feel that a sea system for tracking, surveillance and weapon control similar in design to that in the Atlantic should be in place. Since the main object of west coast defenses will be to protect the northern, central and southern areas of the coast and since there are many miles between this coast and heartland targets, we feel that the depth of the data zone need be only 700 miles to seaward in the Pacific. Using the same kind of combination of shipborne and airborne radars as for the Atlantic and arranging five YAGR picket stations and 3 flight patterns with 6 aircraft airborne in each, as shown in Fig. 12C-1, a data zone in the Pacific can be established that will meet our objectives. The picket ships are YAGR's, as in the Atlantic, with all the 1960 electronic refinements previously discussed. The aircraft are the improved version of the WV-2 with the high-performance radar. The only difference between the Atlantic and Pacific in 1960 is that the depth of the data zone in the Pacific is not so great. Thus, forces required in the Pacific are lower than for the Atlantic sea-approach system.

> 10 ships, 2 ships/station. This back-up factor is subject to the same suspicion as that previously mentioned for the Atlantic stations.
>
> 90 WV-2, 5 aircraft/one airborne.

The YAGR's required here are entirely new forces since all previously programed YAGR (plus a few more) have already been used in our sea system in the Atlantic. If by 1960 a warning line between Midway and Adak were established in lieu of the 1957 line between Pearl Harbor and Kodiak, it is possible that some WV-2 aircraft would become available (because of the lesser forces required in the Midway-Adak line) for use in this solid surveillance and tracking system. In any event, additional naval aircraft and ships over those now programed will be required by 1960 to implement this system.

The quality of the data within the system in the Pacific would be of the same order as in the Atlantic. Since the depth of the zone is only 700 miles, however, we believe

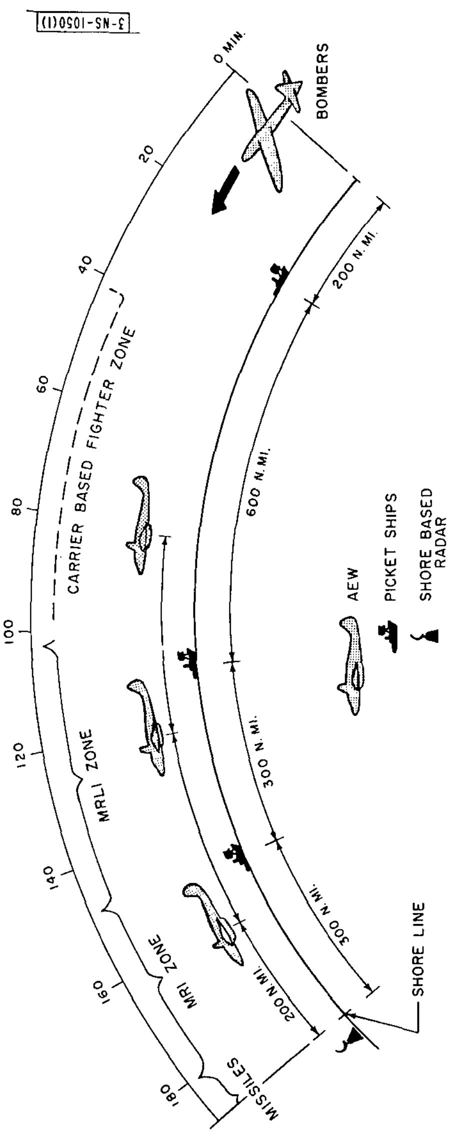


Fig. 12E-1. Contiguous data zone, overwater profile, carrier-based fighter zone.

that any fighters arrayed for combat use in this area should be shore-based. Accordingly, we do not believe that there would be any benefits to be achieved from the use of carrier-based fighters continuously available in the environment. But, as in the Atlantic, we believe that during certain conditions of alert it would be most plausible that the defense forces located ashore should receive important augmentation from the carrier striking forces that happen to be operating from west coast ports prior to D-day. This, of course, would be entirely dependent upon the strategic deployments of the Pacific carrier striking forces that may have been made to the Western Pacific in advance of D-day.

It is possible, then, in the year 1960, to establish in the Atlantic and Pacific Oceans a sea system for surveillance and tracking of air, surface and subsurface targets. The system should be viewed as one that provides a service to Cincconad, Cinclant and Cincpac in order that they may make decisions related to taking counteraction against attacks on the U.S. The product of this sea system, in addition, would be one that these commanders can use in bringing whatever defense weapons they have available to bear directly upon inbound attacks. We feel that through this system they could fight a manageable battle against attacks that may develop through the ocean areas and start these battles remotely enough from the critical target areas to discharge their defense responsibilities. It is important to mention that the establishment of a system at sea for surveillance, tracking and generating weapon direction data does not mean that any of the three commanders involved would relinquish operational control over the weapons he is normally assigned. Rather, the system will allow him to make sound decisions relating to how many weapons he will commit to battle in the ocean areas and at what rate, in view of the tactical situation surrounding the North American continent. Once a commander has decided to commit fighter forces into the sea areas, the aircraft will be able to receive accurate vector data either from the ships or the AEW aircraft of the system, thus enabling the pilots to join combat.

Figure 12E-1 is a cross section taken perpendicular to the East Coast of the U.S. If this bomber represents a raid approaching the U.S. at high altitude at about 500 knots, it would be possible to make interceptions with carrier based aircraft, if they were operating in the area, at a distance offshore about 1000 to 650 miles. The number of carrier-based fighters brought to bear would be relatively small, but the process of attrition could be started in this area. In the meantime, the data output of the picket ships to shore would be automatically relayed to and displayed as desired at various locations within the Eastern Air Defense Force. If a decision were made 10 minutes

after first acquisition to commit shore-based fighter to this raid (let us assume that such a decision has been made within Eastern Air Defense Force, and let us assume further that the first 4 medium-long-range fighters in squadrons scrambled are airborne at time zero plus 15 minutes), they will join combat at a point about 650 miles from the shore. The first of the medium-range interceptors from the East Coast could make contact with the raid at a point 300 miles from the shore. More and more fighters from the shore can be brought to bear throughout the progress of the raid through this area, until the local or perimeter ground-to-air missile defenses can take the enemy under fire. Thus, we have a way of starting attrition against a large scale raid in the Atlantic at about 1000 miles from our shores and bringing increasing numbers of interceptors into the battle as needed to defeat the attack as it approaches our coast. For a low-flying aircraft flying at slower speeds, the times available to conduct the progressive battle would be about the same. However, first detection of the low flyers, in terms of distance, would not be achieved until a point 1000 miles offshore is reached.

It must be emphasized that the sea system that has been described is one way of improving the defenses of the U.S. against attack through the oceans. We believe, however, that it is reasonable in terms of technical feasibility, operational practicability and national economy. The manner in which this system at sea will also serve the purpose of coping with the surface and subsurface threats against our coasts will be discussed in Chap. 14.

R.W. Mehle

APPENDIX 12-F
DETAILS OF COSTING

Chapter 12 summarizes the cost procedure that have been used. All variations in equipment quantities between the proposed system and ADR 54-60 occur between mid-1957 and mid-1960. It is assumed that the phasing of each additional item is such that the total operating cost for that item for a 3-year period is equal to the maximum quantity for one year. For example, if 10 per cent becomes operational the first year, 30 per cent the second, and 60 per cent the third, then the total operating cost is equivalent to operating 100 per cent for a full year.

Table 12F-1 presents the costs for the Basic Lamp Light System. Tables 12F-II and 12F-III present the costs of the scaled-up and scaled-down variations, respectively. Tables 12F-IV, V and VI present the cost of the systems when the noncontiguous early information line is not included. The grand total in each table is the cumulative cost for FY 1955 through 1960.

TABLE 12F-1

BASIC LAMP LIGHT SYSTEM
(millions of dollars)

	Unit Cap.	Unit Oper. per year	Item Capital	Item Operating
1. Weapons				
ADR 54-60 Interceptors (less LRI & Bomarc Systems)			9149	7588
ADR 54-60 Missiles (Nike)			4068	1985
Plus the following:				
25 MRI Squadrons (F-102B)	72.6	22.0	1815	550
41 MLRI Squadrons (F-101)	70.6	23.5	2896	962
25 Nike B Bn.	17.1	4.2	428	104
			18,356	11,189
2. Surveillance and Weapon Control				
ADR 54-60			2886	3337
Less ADR 54-60 Greenland CW line			−16	−6
Plus the following:				
10 Prime radars	6.0	1.8	60	18
64 AEW&C airplanes	4.8	1.4	307	88
75 Gap fillers	3.0	0.66	227	50
32 Picket ships	5.5	1.0	176	32
Baffin Island – United Kingdom Line				
6 stations	6.0	1.8	36	11
5 stations (Iceland – Faeroes)	4.0	0.6	20	3
4 picket ships	5.5	1.0	22	4
Aleutian Chain				
8 stations	5.0	0.8	40	6
Corrode DEW line			250	45
Alaska Chain				
7 stations	5.0	0.5	35	4
			4042	3592
3. Command Administration and External Support				
ADC Command and Administration			23	416
AF external support				
45.6% of surveillance and AF weapon and operating costs				5763
Command and administration				190
Army				109
			23	6478
Total			22,421	21,259
Grand Total			43,680	

TABLE 12F-II

SCALED-UP VARIATION
(millions of dollars)

	Unit Cap.	Unit Oper.	Item Capital	Item Operating
1. Weapons				
ADR 54-60 Interceptor (less LRI & Bomarc)			9149	7588
ADR 54-60 Missiles (Nike)			4068	1985
Plus the following:				
50 MRI Squadrons (F-1-2B)	72.6	22.0	3631	1100
66 MLRI Squadrons (F-101)	70.6	23.5	4663	1548
65 Bn. Nike B	17.1	4.2	1112	271
			22,623	12,492
2. Surveillance and Weapon Control				
ADR 54-60			2886	3337
Plus the following:				
15 Prime radars	6.0	1.8	90	27
169 AEW&C airplanes	4.8	1.4	259	75
75 Gap fillers	3.0	0.66	227	50
52 Picket ships	5.5	1.0	286	52
Baffin Island – United Kingdom Line (less Greenland CW line, Table 12F-I)			62	12
Aleutian Chain (Table 12F-I)			40	6
Corrode DEW line			250	45
Alaska Chain (Table 12F-I)			35	4
			4686	3766
3. Command Administration and External Support				
ADR Command and Administration			23	416
AF External Support				
45.6% of surveillance and AF weapons and operating costs				6385
Command and administration				190
Army				115
			23	7106
Total			27,332	23,364
Grand Total			50,696	

TABLE 12F-III SCALED-DOWN VARIATION (millions of dollars)	Unit Cap.	Unit Oper.	Item Capital	Item Operating
1. Weapons				
ADR 54-60 Interceptors (less LRI & Bomarc)			9149	7588
ADR 54-60 Missiles (Nike)			4068	1985
Less 15 Bn. Nike B (converted)	24.7	4.2	−371	−63
Plus the follwing:				
16 MLRI (F-101)	70.6	23.5	1130	375
			13,976	9885
2. Surveillance and Weapon Control				
ADR 54-60			2886	3337
Plus the following:				
7 Prime radars	6.0	1.8	42	13
75 Gap fillers	3.0	0.66	227	50
24 Picket ships	5.5	1.0	132	24
39 AEW&C airplanes	4.8	1.4	187	54
Baffin Island − United Kingdom Line (less Greenland CW line, Table 12F-I)			62	12
Aleutian Chain (Table 12F-I)			40	6
Corrode DEW line			250	45
Alaska Chain (Table 12F-I)			35	4
			3861	3544
3. Command Administration and External Support				
ADC Command and Administration			23	416
AF External Support				
45.6% of surveillance and AF weapons operating cost				5247
Command and administration				190
Army				94
			23	5947
Total			17,837	19,386
Grand Total			37,223	

TABLE 12F-IV

BASIC LAMP LIGHT SYSTEM MINUS EARLY INFORMATION
(millions of dollars)

	Unit Cap.	Unit Oper.	Item Capital	Item Operating
1. Weapons				
ADR 54-60 Interceptors (less LRI & Bomarc)			9149	7588
ADR 54-60 Missiles (Nike)			4068	1985
Plus the following:				
25 MRI Squadrons (F-102B)	72.6	22.0	1815	550
41 MLRI Squadrons (F-101)	70.6	23.5	2896	962
25 Nike B Bn.	17.1	4.2	428	104
			18,356	11,189
2. Surveillance & Weapon Control				
ADR 54-60			2886	3337
Less 11 AEW&C airplanes	4.8	1.4	−53	−15
Less Greenland CW line			−16	− 6
Plus the following:				
10 Prime radars	6.0	1.8	60	18
75 Gap fillers	3.0	0.66	227	50
			3280	3416
3. Command Administration and External Support				
ADC Command and Administration			23	416
AF External Support				
45.6% of surveillance and AF weapons operating costs				5707
Command and administration				190
Army				109
			23	6422
Total			21,659	21,027
Grand Total			42,686	

TABLE 12F-V

SCALED-UP VARIATION MINUS EARLY INFORMATION
(millions of dollars)

	Unit Cap.	Unit Oper.	Item Capital	Item Operating
1. Weapons				
ADR 54-60 Interceptors (less LRI & Bomarc)			9149	7588
ADR 54-60 Missiles (Nike)			4068	1985
Plus the following:				
50 MRI Squadrons (F-102B)	72.6	22.0	3631	1100
66 MLRI Squadrons (F-101)	70.6	23.5	4663	1548
65 Bn. Nike B	17.1	4.2	1112	271
			22,623	12,492
2. Surveillance and Weapon Control				
ADR 54-60			2886	3337
Less Greenland CW line			−16	−6
Plus the following:				
15 Prime radars	6.0	1.8	90	27
54 AEW&C airplanes	4.8	1.4	259	75
75 Gap fillers	3.0	0.66	227	50
52 Picket ships	5.5	1.0	286	52
Corrode DEW line			250	45
			3982	3580
3. Command Administration and External Support				
ADC Command and Administration			23	416
AF External Support				
45.6% of surveillance & AF weapons operating costs				6300
Command and administration				190
Army				115
			23	7021
Total			26,628	23,093
Grand Total			49,721	

TABLE 12F-VI

SCALED-DOWN VARIATION MINUS EARLY INFORMATION
(millions of dollars)

	Unit Cap.	Unit Oper.	Item Capital	Item Operating
1. Weapons				
ADR 54-60 Interceptors (less LRI & Bomarc)			9149	7588
ADR 54-60 Missiles (Nike)			4068	1985
Less 15 Bn. Nike B (converted)	24.7	4.2	−371	− 63
Plus the following:				
16 MLRI Sq. (F-101)	70.6	23.5	1130	375
			13,976	9885
2. Surveillance and Weapon Control				
ADR 54-60			2886	3337
Less 36 AEW&C airplanes	4.8	1.4	−172	−50
Less Greenland CW line			−16	−6
Plus the following:				
7 Prime radars	6.0	1.8	42	13
75 Gap filler	3.0	0.66	227	50
24 Picket ships	5.5	1.0	132	24
			3099	3368
3. Command Administration and External Support				
ADC Command and Administration			23	416
AF External Support				
45.6% of surveillance and AF weapon operating costs				5167
Command and administration				190
Army				94
			23	5867
Total			17,098	19,120
Grand Total			36,218	

APPENDIX 12-G

DETAILS OF HEARTLAND PERIMETER DEFENSE

LAND INSTALLATIONS

There are 34 land installations in the perimeter itself and six "filler" installations inside. The location of the "filler" installations is shown on Fig. 12-12. The other installations are evenly spaced about 55 nautical miles apart on the northern side and 60 nautical miles on the southern side of the heartland.

Each land installation consists of two Talos batteries including the following total equipment:

	Roundhouse for missile storage,
4	single-rail launchers and related loading gear,
12	transmitters for mid-course guidance of missiles,
4	radars for fine tracking and illumination of the target,
1	acquisition radar,
	data link to SAGE System,
60	Talos L missiles (HE warhead),
60	Talos LW missiles (special warhead).

It is assumed that the target-illuminating radars are located on a 450-foot tower of light construction, which adds 25 miles to the effective range of the Talos L against very-low-altitude targets.

SEA INSTALLATIONS

Each installation at sea represents one converted Liberty ship with the following total equipment:

	Above-decks storehouse for missiles, ready to fire,
2	dual launchers and related loading gear,
12	transmitters for mid-course guidance of missiles,
4	radars for fine tracking and illumination of the target,
1	surveillance radar (SPS-6B or better)
	data link to SAGE System,
48	Talos L missiles, (24 for each launcher),
48	Talos LW missiles (24 for each launcher).

These ships may be anchored or may move about slowly with their exact location determined by radar from shore. It is assumed that 4 ships are required for each 3 on station, and that 1-1/2 crews are required for each ship on station.

RELIANCE ON SAGE

The following information from SAGE is used by both land and sea installations:

- Warning to prepare for firing,
- Identification friend-or-foe,
- Specific location of targets below the horizon or beyond the range of the local surveillance radars; this permits launching and initial guidance of missiles against incoming targets,
- Command decisions.

However, using its own surveillance radar and available IFF techniques, each installation can continue to function at reduced range and rate of fire even if SAGE is operative.

FIRE POTENTIAL OF THE LINE

The fire potential of this perimeter line, against a highly concentrated raid at 500 knots and above 3000 ft would be as follows.

	Salvos*	
	Min.	Max.
Land, all Talos L	120	160
Land, all Talos LW	128	164
Sea, all Talos L	112	118
Sea, all Talos LW	178	187

*"Salvo" means either a single Talos LW or a pair of Talos L missiles.

The fire potential against targets below 3000 feet reduces approximately linearly to roughly half the above values at 500 feet.

These values increase considerably when greater raid length and width are taken into account.

FURTHER REFINEMENTS OF THE CONCEPT

Preliminary evaluation of this concept has brought out that, with even spacing of the sites around the perimeter, it appears very probable that the enemy will penetrate the line immediately adjacent to the small number of target cities he has decided to attack, and will not otherwise enter the heartland. This suggests that the concept would be improved by reducing the spacing in the "most probable" areas at the expense of increased spacing in the less probable areas. It is likely that, by this means, at least 50 per cent improvement in capability of the perimeter (against both wave attacks and prolonged attacks) can be obtained at the few most likely targets.

A second refinement appears to be warranted in the case of the land portion of the perimeter line; this is to use single batteries at half the spacing of the present double batteries. Whereas there is a serious reduction in the capability of the presently proposed line against low-altitude crossings midway between sites, the loss in capability would be virtually eliminated by the halved spacing. A second advantage of this break-up would be reduced vulnerability to being bombed out.

These two improvements have not been worked out in detail because of the limited time available for their description and evaluation.

L.K. Edwards

APPENDIX 12-H

THE CONTINENTAL DEFENSE VESSEL

In the course of the Lamp Light study it became apparent that the picket vessels deployed in the contiguous defense zones may be required to have characteristics different from those of any existing type of ship. The Liberty ship YAGR's presently programed were planned for use in inshore waters only, and it is questionable whether they are sufficiently seaworthy to keep station for long periods in the open Atlantic at distances up to 1000 miles offshore. Moreover, as the equipment needed for the 1960 time period was examined, it was clear that if the ship is to carry all the proposed equipment the original hulls will have to be extensively modified, and it might be preferable to design a new hull to suit the specialized requirement. This is especially true since the Liberty ship hulls are already old, and by 1960 they will be near the end of their useful life.

The most far-reaching effects on the ship design will arise from the requirement to carry a very large rotating radar antenna. This was discussed in Chap. 4, where it was proposed that an antenna with a horizontal dimension of about 45 feet or larger would be desirable. The physical problem of making room aboard a Liberty ship for such an antenna is a formidable one. In addition, the maximum possible stability is required for the air search and interceptor control function as discussed in Chap. 7 and Appendix 7-D. This will probably entail stabilizing the antenna, or the vessel, or both. Either alternative will influence the ship design considerably.

In connection with the stabilization problem, some calculations have been made of the motions of a Liberty ship in rough weather. These calculations are presented in Annex 1 to this Appendix as examples of the conditions under which shipboard equipment may be required to operate, and as an indication of the magnitude of the stablization requirement.

Other equipment which it is proposed should be fitted in to the continental defense vessel includes Phase 2 data-processing equipment, improved communication facilities, IFF equipment, shipboard passive listening gear for submarine detection, long-range low-frequency active sonar and one or more ASW and general-purpose helicopters. It is clear that many space and weight problems will be involved in fitting this equipment into a single ship.

It was also considered that the important characteristics of the continental defense vessel may be sufficiently different from those of conventional ships to justify consideration of novel hull designs. The stability problem will be of greatest importance. Also, the

location of the vessel must be accurately known and preferably should be fixed so that the design should be for best efficiency of station-keeping rather than of movement from one place to another as it is for conventional ships. Furthermore, maintaining stations at sea is similar to maintaining arctic stations in that the number of personnel required should be kept to an absolute minimum. The essential personnel are the equipment operators, and each man required for operating the vessel itself adds a large overhead cost because of the extra logistics, services, space, etc. This fact must be given great weight in the design, since economic operation is mandatory for the continuous, long-term type of operation involved in continental defense. For these and other reasons it was recognized that the optimum design of a continental defense vessel might prove to be a departure from standard ship designs.

The tests carried out to date by the Sun Shipbuilding Company* on the Armstrong floating platform or "sea-drome" have shown sufficient promise of success to justify further investigation. The principle of construction of the "sea-drome" is that a platform is supported about 50 feet above the water on a number of floats, each of which is a vertical cylinder ballasted at the lower end and extending to depths of 150 feet or more. There is suitable cross-bracing between floats. The tests of a $1/25^{th}$ scale model in waves of various amplitudes and lengths have shown that the structure should have excellent stability characteristics. Still to be resolved is the seaworthiness of a full-scale model in the rough-weather conditions that are actually encountered at sea. There is evidence to show that the problem of anchoring a platform of this type in very deep water can be solved. Power requirements for propulsion should be low, i.e., sufficient only to maintain heading and reduce strain on the anchor cable during rough weather. It is anticipated that under exceptional condition – for example, if the platform were caught in the path of a hurricane – it would be necessary to cut adrift from the anchoring buoy. This would necessitate later recovery and repositioning by a service ship.

In view of the manifest advantages accruing if a vehicle could be designed with substantially improved stability, capable of being anchored in deep water, and probably requiring fewer operating personnel, it would seem that the feasibility of this method of construction should be examined very carefully before it is rejected as impracticable.

Other designs that have been suggested included exceptionally deep draught ships which might have added stability, and standard ship shapes with Denny-Brown type stabilizers

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*Final Report on Sea-Drome Model Tests, War Department Contract W-44-009-Eng. –340 between War Department and Sun Ship Building and Dry Dock Company, Chester, Pennsylvania, and Sea-Drome Patents, Inc., Philadelphia. Contract signed 21 January 1946.

(see Appendix 7-D) which makes use of the forward movement of the ship operating on small hydrofoils to reduce motion.

Lack of time and personnel limited the work to a brief preliminary survey. It is recommended that much further effort be put into this type of study as future picket-vessel forces are procured.

N. J. Hopkins

ANNEX 1*

MOTION OF LIBERTY SHIP HULLS IN ROUGH WEATHER

The accompanying diagram shows results of calculations of the maximum movements, velocities and accelerations which may be encountered during rough weather at various points in a typical 10,000 ton Liberty ship hull. The results are based on measurements of the amplitude and period of roll and pitch made on board the S. S. "Ocean Vulcan" (Ref. 1) and on studies of the motion of ships by J. L. Bartlett (Ref. 2). The measurements were made over an 18-month period while the "Ocean Vulcan" was plying between Western Europe and the East Coast of the U. S. on normal peacetime trade routes. The results of interest in the present context are reproduced in Fig. 12H-1. They are averaged over all seasons of a typical year, and should be representative of conditions to be expected over most of the Atlantic.

In Ref. 2 it is concluded that for all practical purposes the period of pitch and the period of heave are equal, and also equal the period of encounter (time required for a wave crest to travel the length of the ship). Also, the maximum motions occur when the wave length is approximately equal to the waterline length of the ship. In the case of the "Ocean Vulcan" this is 416 feet, and if the ship sails at 8 knots into waves of length 416 feet, the period of encounter is 7 seconds. For the calculations to follow, this is assumed to be the shortest period of pitch and heave that is likely to occur. As shown in Fig. 12H-1(b), the measured frequency of occurrence of this period is very low.

Empirical results have shown that for head-on encounter the point of pitching will be located approximately 66 per cent of the waterline length of the ship from the forward end of the waterplane.

The maximum semiamplitude of pitch was taken as 5.37°. This is the value given in Ref. 2 for the slope of waves of 470-foot length (the nearest value to 416 feet that is listed). The slope is used since in the limiting condition the semiamplitude of pitch will equal the wave slope. From Fig. 12H-1(a) (integrated) it was determined that amplitudes of pitch greater than this were observed during less than 3 per cent of the time.

The maximum amplitude of heave was taken as 15 feet since the heave amplitude will be approximately equal to the wave height and the latter was given as 14 feet for the 470-foot waves previously considered.

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*The material in this Annex is UNCLASSIFIED.

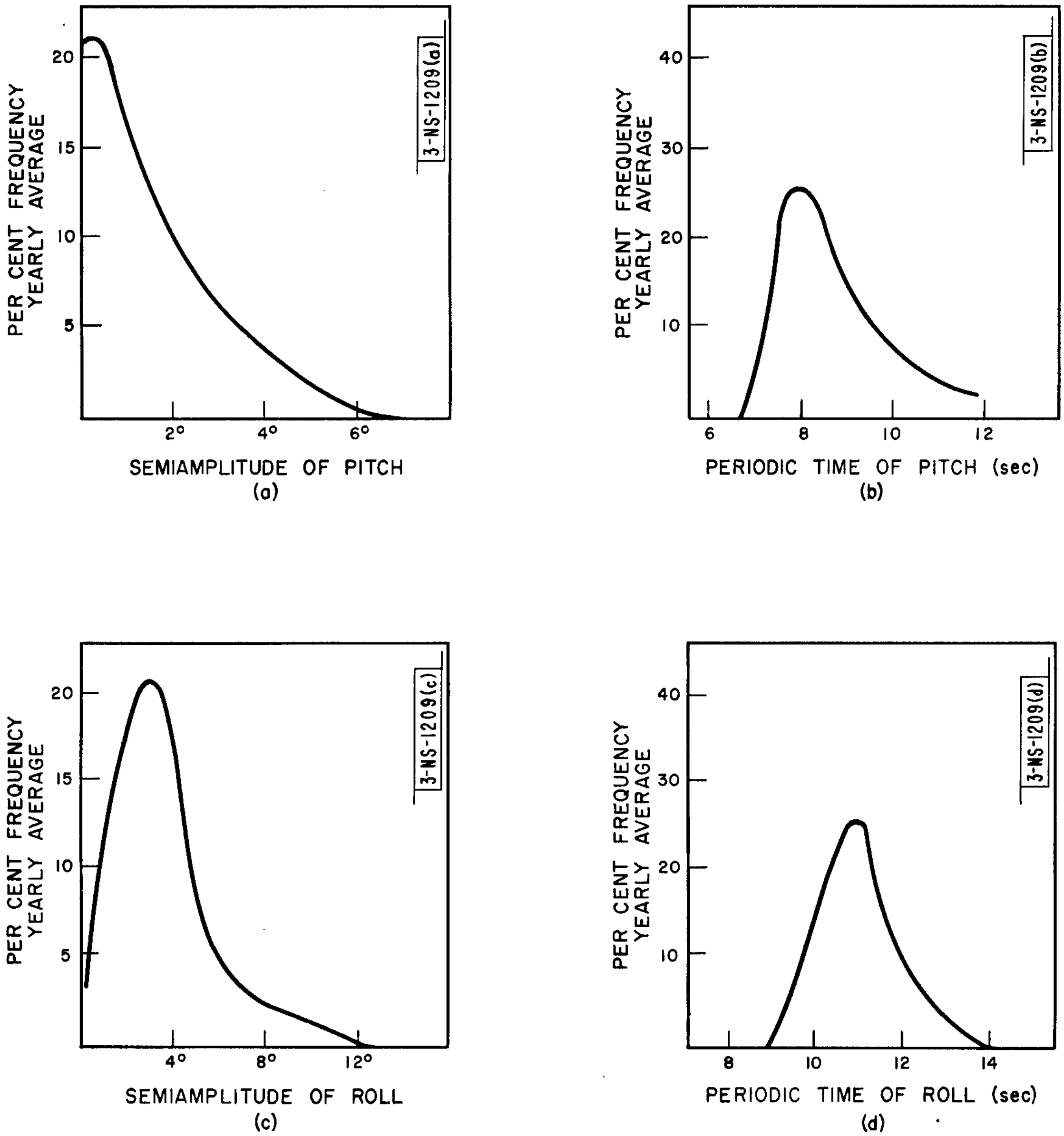
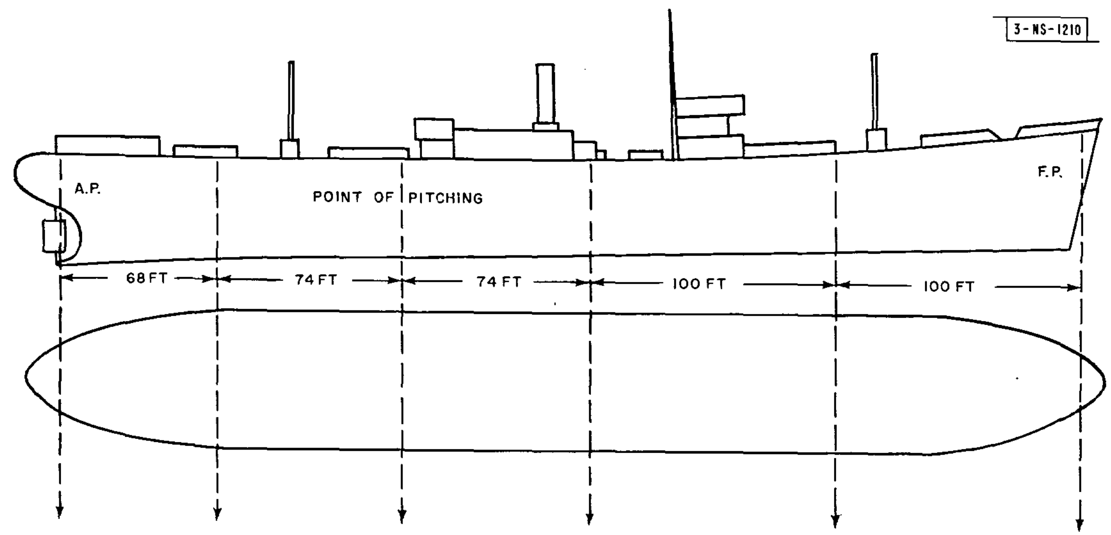


Fig.12H-1. Measured amplitudes and periods of pitch and roll in S.S. "Ocean Vulcan".



Center Line						
Movement (ft)	41.4	28.7	15.0	28.7	46.4	66.0
Velocity (ft/sec)	18.3	12.6	6.5	12.6	20.6	29.4
Acceleration (ft/sec)	16.8	11.6	6.1	11.6	21.8	26.8
10 feet from Center Line						
Movement (ft)	45.6	32.9	19.2	32.9	50.6	70.2
Velocity (ft/sec)	20.3	14.6	8.5	14.6	24.6	31.4
Acceleration (ft/sec)	23.3	18.1	12.6	18.1	37.5	33.3
20 feet from Center Line						
Movement (ft)	–	37.1	23.4	37.1	54.8	–
Velocity (ft/sec)	–	16.6	10.5	16.6	24.6	–
Acceleration (ft/sec)	–	27.3	21.8	27.3	37.5	–

Fig. 12H-2. Calculated maximum motions of 10,000-ton Liberty Ship.

For roll motion the semiamplitude and period to be used in the calculations were taken as 12° and 9 seconds, respectively, obtained from Figs. 12H-1(c) and (d).

Pitching and heaving motions are closely sinusoidal and the calculations of movement, velocity and acceleration are straightforward. Roll is more complex, but empirical results show that it can be treated as simple harmonic motion and subsequently corrected by adding 33 per cent to the calculated velocity and 60 per cent to the calculated acceleration (Ref. 2).

In order to calculate the maximum motions that are likely to occur even momentarily (excluding very exceptional circumstances), it was assumed that the largest amplitude of each motion coincided with the shortest period and that all three motions occurred in phase.

Under these conditions the results shown in Fig. 12H-2 were obtained for movement, velocity and accelerations at points along the center line of the ship and at points laterally displaced by distances of 10 and 20 feet from the center line.

N.J. Hopkins

REFERENCES

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2. J.L. Bartlett, "The Motion of an Aircraft Carrier at Sea in Relation to the Operation of Naval Aircraft," Trans.Inst. Naval Architects, London (1953).

CHAPTER 13

THE REMOTE INFORMATION ZONE

CHAPTER 13
THE REMOTE AIR DEFENSE ZONE

THE REMOTE ZONE

The Remote Zone is a geographical region of military importance in which some surveillance and tracking information is sought. In the limit, the Remote Zone extends from the perimeter of contiguous coverage up to the territory controlled by the enemy. In Project Lamp Light, this zone has been studied with two objects in mind: (a) securing early information; (b) extending the combat zone. The usefulness of these two objectives and their possible achievement will be discussed hereafter.

Information

The purpose of "information", in the sense used herein, is to provide enough grounds for warning decision. "Warning" is a subjective matter, a command decision that is not objective or automatic. "Warning" is taken by a commander as a result of his evaluation of various bits of information, some of which may be highly significant while others by themselves are of little value. Thus, all bits of information concerning air movements – enemy, friend or neutral – can have value. Consequently, means of seeking information can range from systems giving complete, unambiguous data that can automatically determine warning, to more diffuse systems adding small increments to a total picture. No single warning system proposed can be considered foolproof or free from troubles. Combinations of systems are, in general, much more reliable in over-all result as will be discussed in a later section.

The weight to be attached to any discrete piece of information in determining warning should be varied in accordance with the relative cost to the enemy, and to the cost to us if the information is misinterpreted and ignored. For example, in air defense, warning may clearly be taken if a large group of unidentified aircraft crosses a line well beyond its estimated point-of-no-return.

Ideally in the air defense case, we would prefer to collect information in all parts of the air space between the enemy's territories and our targets. This would permit greater accuracy in decision, but might be too costly. A practical system must balance the anticipated performance against cost and is thus bound to be a debatable compromise. In this, the search for information, like the search for truth, can neither be wholly successful, nor entirely fail.

Need for Information:– Of what value is the information we seek, or the warning we hope to derive therefrom?

Methods for obtaining distant information against a mounted enemy air attack have been suggested a number of times. These proposals and the studies or reviews stemming from them have indicated a number of valuable benefits obtained by the presence of early information. Although these have been stated many times and are by now widely accepted, it is advisable to restate them briefly.

Alert SAC:– In the immediate time period, four hours minimum is required to secure the flyable planes of the Strategic Air Command (SAC) in case of enemy strikes. This can and is to be reduced in later time periods; however, a distance from the warning net yielding similar warning time will then be required to (a) give improved opportunity to launch counter-blows, not merely "fly-away" scattering of bombers; and (b) counter a possible increase in velocity of enemy aircraft.

Alert CONAD:– To obtain the availability of maximum number of interceptors in the air defense system, 2 to 3 hours are needed today. In addition, such warning permits improving the quality of plotting and control teams, and after the introduction of the SAGE System will allow the most experienced teams of intercept directors to be placed on duty.

Ground Civilian Air Traffic:– The effectiveness of the air defense system can be greatly improved by eliminating civilian air traffic from the continental combat areas. One and one-half hours minimum is necessary for this.

Alert Defense Department:– Warning of 2 to 6 hours permits other military agencies of the Department of Defense to take appropriate action, e.g., naval forces in continental ports may be placed on alert.

Augmentation Forces:– Warning of 4 to 8 hours permits additional augmentation forces of interceptors to be placed at the disposal of Continental Air Defense Command (CONAD). As in the case of SAC, this time requirement should be reduced in future periods.

CONELRAD:– The denial of electromagnetic navigation aids to the enemy may be undertaken much sooner while he is still remote from his goal and when bad navigation is more costly to him.

Civil Defense:– In case of mass penetrations of the distant information system, immediate action by Civil Defense authorities is possible. In any case, the Civil Defense officials can be warned of small penetrations and take appropriate steps to contact the volunteer staff.

Time to Think:– Almost the greatest benefit is obtaining time to think, to consider the situation and to decide on the best action. For example, if the number of "bogeys" in the local air defense system has approached the stipulated levels, it is most important to know that no additional unknowns are within 2 to 4 hours of the Air Defense Identification Zone (ADIZ); this gives a commander time to consider and refrain from taking extensive and costly action, pending the identification of one or more temporary unknowns. It has also been suggested by study teams in the Department of Defense that added time permits SAC to delay the decision to take off while still retaining the ability to get all flyable aircraft off the ground before attack. In this connection, the value of additional warning time increases up to any times conceivably achievable by practical placement of a distant information system.

Consideration of the above has led us to these conclusions:

> For two systems of equal reliability and approximately comparable costs, it is wiser to select the system offering greater warning time – because of the value of 2 to 4 hours warning and because airplane speeds (increasing with time) will reduce this warning time in later periods.
>
> A considerable price can be justified for data that produce the maximum of unequivocal warning. We feel that only continual surveillance of enemy activities over the whole air space can produce the maximum warning time, but we agree that such surveillance will probably be too expensive for the result obtained. A somewhat reduced level of surveillance will, we believe, produce an almost equally useful result and will release funds for more active defensive measures. Since it is unlikely that true warning can be taken until the enemy passes beyond his point-of-no-return – or crosses over our sovereign territory or that of our allies, or performs some overt act of hostility, or proceeds in force far beyond his usual haunts in a direction where he is dangerous to us – it appears that a moderate degree of surveillance is all that is justifiable in remote regions. This moderate degree of surveillance must, however, be so designed as to focus our attention on the enemy's movements and, where possible, be so designed as to deny to the enemy any large chance of proceeding far on his mission, hostile or non-committal as the case may be, without coming under observation.

We have examined the advantages to be obtained from distant information sources. What expenditures can we justify to secure those advantages? One approach is to examine curves of readiness for CONAD, SAC, and other military organizations. Such curves all show an increase in effectiveness with increase in warning time. Let us suppose that the effectiveness of Air Defense Command (ADC) operations (on some appropriate scale of performance) could be increased from 50 to 60 per cent by increasing the warning time from 60 to 90 minutes. On a linear extrapolation, this 20 per cent

increase in effectiveness would be worth 20 per cent of the present investment in fighters, base facilities, air crews, control radars, etc. This alone is a very large sum. Additional expenditures can be justified by the benefits obtained by SAC and other defense agencies. While exact figures can be obtained only from a much more detailed analysis, these very approximate considerations suggest that it may be wiser to spend dollars for additional warning time rather than for additional weapons.

Methods:– To provide information from a Remote Zone – information from which we may derive warning – two different methods are available:

> The provision of relatively tight, planned barriers of thickness 5 to 200 miles, placed in locations chosen to result in high probability for detection of enemy penetration by even a single plane.
>
> Surveillance of broad areas, many hundreds or thousands of miles in each dimension.

The latter is clearly the superior approach since more data are obtained, spoofing is made practically impossible, and destruction or accidental loss of small portions do not open detection-free avenues to our contiguous zone. However, the cost for a continuous system giving high and low cover may be great. Examination of the problem has indicated that a less solid system has benefits and, indeed, even some especial merit when used in combination with a solid barrier or system of barriers. An occasional report on the enemy progress is all that is required, and a figure of between one and two reports per hour might well be sufficient. It is necessary that he have no way of absolutely avoiding surveillance, so that cover at extreme altitude is needed, and all practicable strike routes must be covered at least occasionally. It might be worth while to consider the enemy planner's attitude towards surveillance or detection or tracking probabilities. While a defense commander might justifiably demand a 75, or 90, or 99 per cent cumulative probability of detection before some arbitrary point is reached along an arbitrary flight path, the attacking commander may be looking for a 75 or 90 per cent probability of evading detection and recognition. If this is not attainable, then he may not feel justified in attempting a sneak attack and may well be reduced to the more readily recognized mass attack. A mere 25 per cent detection probability increases the enemy's problems, although at first glance it does not appear to help us greatly. It is, of course, important that such a low observation probability be spread over all possible strike routes, be available at all times, and that its absence from a particular place be unpredictable. This will be discussed at greater length in a later section.

What are the tools we may use in constructing these barriers and surveillance zones? Lamp Light has considered a number of methods which are summarized here.

Land Barriers:— We endorse the principle already demonstrated in Project Corrode and adopted for the Mid-Canada Line and the scheduled DEW Line (Western Electric Project 572) that stations for detection should base their primary reliance upon radar methods, either conventional scanning radars or Fluttar radars (McGill type) as are appropriate to the location, with combinations employed where advantageous to complicate jamming or spoofing. The radars themselves represent types now well understood and pose no new fundamental problems, merely engineering solutions in a well-standardized field.

Airborne early-warning (AEW) patrols over land offer an attractive tool. As of 1955, these are not practical because airborne moving-target indication (AMTI) for use over rough terrain is not sufficiently developed. It is extremely unlikely that this can be available before 1958 in even small degree. In this respect, the air-to-air search situation is markedly different from the ground-to-air search case discussed above. However, AEW over water is now available for planning.

The communication methods are well understood also but must be carefully thought out. No doubts need exist as to the possibility of providing communication networks with reliability of warning transmission in excess of 95 per cent. Again, the methods already demonstrated in Project Corrode, Project Pine Tree, Limestone-Goose Bay-Bluie West 8-Thule, and planned for the Mid-Canada Line give us a sufficient arsenal of methods.

Sea Barriers:— The primary tool for sea barriers is the high-flying AEW aircraft. It is the opinion of Lamp Light that this forms a strong combination when used with a few picket ships for communication and information filtering. Picket ships alone can be used for providing cover, usually low-cover fill-in, in connection with land lines separated by long overwater hops. In general, picket ships are too costly to be used alone for complete barriers when low cover is required.

Land Surveillance:— This method can best be represented in this report by considering the area of Canada north of 55°. Many stations already exist as communications posts of the Royal Canadian Corps of Signals, the Royal Canadian Mounted Police, the Department of Transport Meteorological Division, and commercial organizations. By placing suitable alarm radars at a number of such points, very complete high-altitude coverage and relatively good low-altitude cover is obtainable. In general, the

communication organization must be designed and tailored to fit the locations chosen, and to report to communication centers of the DEW and mid-Canada lines.

Sea Surveillance:– By placing alarm radars on merchant ships controlled by or friendly to the United States, Canada, or the United Kingdom, the same sort of coverage is available at sea. Here one reaps the added benefit that any existing low-altitude gaps move with the changing pattern of ship position and are thus not predictable by ferret search.

Interrelation of Barriers and Area Surveillance:– There are several aspects of the use of barriers and of area surveillance that are not immediately obvious.

Random Positioning:– If, for reasons of expense, one cannot afford to cover an area completely at high and low altitudes, then one weighs the value of partial coverage. War games during Lamp Light have indicated that advantage accrues to the defending commander from the receipt of occasional reports of position of an unknown or a raid even when less than one-quarter of the route has coverage. If we place our detection stations at existing sites, in part accidentally, then, rather than by pattern or plan, we may make any flight plan designed to avoid detection completely impossible because of the many changes of course with consequent navigation difficulty. If in addition, as at sea, the detection stations are themselves shifting position, any planning to avoid random reports is quite out of the question.

Sensitivity to Raid Size and Altitude:– Area surveillance by randomly placed stations improves detection response against large raids dispersed in distance or in time. It is also better against high-altitude raids. Both these are types of attack that may be considered critical. A penetration at low altitude of a tight barrier, followed by few reports (because of low altitude) gives as much time for decision, preparation, action (because of generally lower plane speeds at low altitude) as does better and more frequent information on a very fast high-altitude raid. Similarly, an extensive penetration with planes spread over perhaps 100 miles laterally will give many more reports than the penetration by one or a few planes. (One plane or a few planes can be safely handled by the contiguous interception system.) Very fortunately, a random area surveillance system and a system of tight barriers complement one another excellently in many respects.

Spoofing:– As pointed out previously, it is advantageous to obtain the earliest possible information. However, this implies proximity to the enemy. Hence far-distant barriers can be "spoofed" with relative ease by an enemy who regularly carries out training exercises in the observation range of such lines. The information from

such lines is thus degraded in value. Surveillance in areas adjacent to the barrier greatly stiffens the barrier against spoofing by providing further information concerning the enemy's movements from which his intentions can more accurately be deduced. Thus the outer barrier serves to alert the commander, but does not require immediate, costly, military action. Warning can be taken from the nature of subsequent reports. Suppose, for example, that we have a barrier in the ocean 1200 miles from the enemy. Penetration of this barrier by 15 to 30 planes could be a training mission, or an act of war. Alerted by their penetration, a report about one hour later at a point 600 miles nearer the continent indicating passage of 10 or more planes eliminates all doubts, assuming this is beyond the point-of-no-return.

Back-Up:– If a tight barrier were the only warning line, the enemy gains considerable advantage by diverting some of his striking strength to knocking out a hole 200 to 300 miles across in this barrier. Naturally, means for back-up must be planned, although any short-time solution must await satisfactory AMTI. Consider now how a randomly placed area surveillance behind the line supports the line. The loss of two or three barrier stations alerts the command to the state of war; the area surveillance accurately reports the strength and nature of the raid or raids with adequate warning time before they reach the fighting zone. The area surveillance detection centers are too numerous to be completely silenced; quite possibly the enemy, knowing this, will not feel it profitable to divert strength to knock out the barrier since detection and observation are inevitable.

The above could lead to the conclusion that loose random surveillance alone is adequate. This is not the case. The tight barrier can be made arbitrarily tight; the information therefrom is of high quality and may be adequate alone. Inaccurate reports from a surveillance net can be correctly evaluated when a "solid" report from good radar observation gives confirmatory information concerning numbers and velocity. In addition, the barrier's communications are most important.

Communications:– The barrier requires its own communication system. This provides the skeleton on which the reliable warning network for the random area surveillance may be hung; this makes it easier to expand the area surveillance as experience dictates.

In the oceans, particularly, it is difficult to decide how far a tight barrier must extend to be effective. If all barriers are backed up by area surveillance, undetected end-runs become nearly impossible and the distance on the strike path penalizes the enemy in range and in warning time.

Suppose that one devises a system of surveillance or information gathering that examines all the air space and sea space of interest only intermittently, and with only a small fraction of these spaces being simultaneously observed. Suppose, further, that this system is so designed that the cumulative probability of detection and recognition is always statistically high enough, far enough away from the targets, to allow adequate warning. It is apparent now that the enemy cannot examine our system and plan flights through it which give low probabilities of detection. The system alters itself before his flight can be made. Even if he carries extensive intercept equipment, we should be able to arrange our system so that there is a fair chance that he will blunder into the area of observation of an information source which, operating intermittently, has just commenced operation. Again, the enemy can be presented with a dilemma as to whether he can get a raid of any significant size through without being observed, even if he employs special tactics. Since he may well fail, he may choose not to try special tactics if they cost him range or time or both.

Gaps in Tight Warning Lines:— The advantages of placing tight warning lines in fixed positions are many, chiefly in cost (both initial and annual) and in reliability. However, gaps in the form of low-altitude tunnels may necessarily be left in the design of such lines or may occur later due to accidental or deliberate destruction of one or more elements of such a line. To close such gaps, mobile data sources may have to be employed. It seems clear that the arguments applied in the case of wholly mobile surveillance now apply to these gaps. Randomly timed coverage amounting at each gap to a small fraction of the total time is adequate, so that the enemy does not have a large enough chance of getting through to dictate a choice of a devious, evasive strike route. The active time of the gap filler may be very erratic, the gaps may remain open for perhaps days on end, and the same principle applies.

Time Periods:— Surveillance can be implemented without reference to specific time periods. Barriers, because of their coherent nature, require scheduling; for these, therefore, three time periods are considered.

Present Period 1955-1958	Before the end of this period, the programmed DEW Line (Western Electric Project 572) becomes operational. Steps must be taken now to extend the barrier when the DEW is working, using AEW aircraft and picket vessels.
Near Period 1957-1960	During this period, additional warning elements could be made operational. This would permit redeploying some of the AEW aircraft (used above to extend the line) to more advantageous locations. Additional equipment types become available in this period.

Far Period 1960-1965 — This period is largely set by the date for implementing the more distant phases of the fighting systems, and is more concerned with them than with changes in the distant information system for other purposes.

Description of Barriers

The barriers described in this section have been selected with the following principles as a guide:

> Barriers have been outlined to bar undetected enemy penetration at high or low altitude. In selecting locations for such barriers, geography has been utilized to the best practical advantage to permit land-based detection lines with a minimum of AEW and picket-vessel usage, this for two reasons; the technical art is better advanced for land lines; the cost of both initial and (especially) annual operation is substantially lower.
>
> Surveillance is advocated to back up the barriers.
>
> Note should be taken that, in laying out barriers and surveillance areas for scanning radars, no advantage has been taken in the computed coverage because of the greatly enhanced target cross section in lateral aspect. This should increase probability of detection both in barrier and area surveillance for targets passing the radar, and is an additional dividend to the information system that is not available to the fighting systems.

Present Period 1955-1958:— The existence of the DEW Line of land-based radar stations with reinforced low cover (Fluttar) is assumed in the latter part of this period. This provides coverage from Cape Lisburne (Alaska) to Cape Dyer (Baffin Island) — see Fig. 13-1.

At the western end, the Alaskan Air Command (AAC) chain of radars provides coverage around Alaska to Kodiak Island. By radar improvement, this coverage can be made adequate for high-altitude flights. Low-altitude coverage is markedly inadequate for defense of Alaska, almost adequate (due to depth of radar cover) for warning to the United States and Canada. At the eastern end, a gap exists between Cape Dyer and the most northerly site of the present Project Pine Tree (Labrador-Baffin Island) line. The Pine Tree radars themselves are too close to the contiguous zone to fulfill our criteria on length of warning time. Both ends, then, of the DEW Line are left exposed.

Alaska-Hawaii:— In the Pacific, the line should be extended by using programmed AEW aircraft and pickets on continuous patrol from Hawaii to Kodiak Island. Such patrols should be mounted as soon as the DEW Line is ready even if 100 per cent time

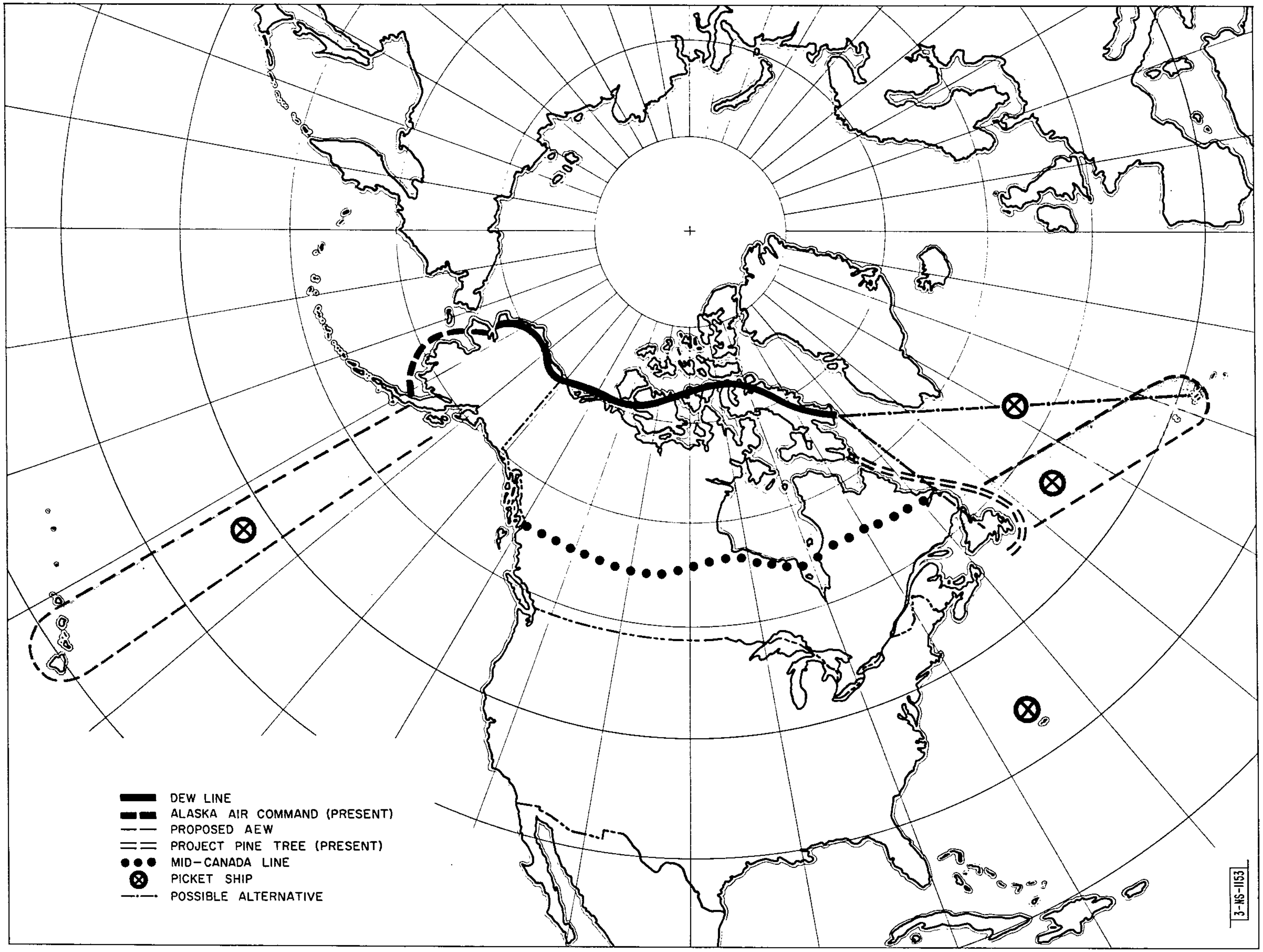


Fig. 13-1. Remote Information Zone, 1955-58. DEW Line, with reinforced low cover, from Cape Lisburne to Cape Dyer. Sea wings from Kodiak to Hawaii and Argentia to the Azores.

coverage of the line cannot be maintained with the AEW planes available, since such a patrol, even if incomplete, greatly complicates enemy planning.

Argentia-Baffin Island-Azores:– During this same period, AEW aircraft from Argentia should periodically close the gap from Cape Dyer to Cape Farewell (Greenland) and should maintain a barrier from Argentia to the Azores (see Fig. 13-1). As before, it is more important to obtain 100 per cent coverage in geography than 100 per cent coverage in time. The measures proposed above are admittedly inadequate but are valuable stopgaps pending the completion of items discussed below. Surveillance systems, as later described, are not tied to firm time periods but grow continually. Some area surveillance should be installed and working in the period 1955-1958.

Near Period 1957-1960:– During this period, vigorous attempts must be made to remedy the inadequacies of the measures provided above. The items suggested below will prevent end-runs, provide more warning time, improve low-altitude detection, exploit programmed radars elsewhere and, by reducing the number required, free AEW aircraft for other uses. The steps to be taken are listed below.

Aleutians:– A line of 8 land-based radar stations of Corrode type with some Fluttar low-altitude reinforcement should be established from the central Alaskan peninsula to Adak, at least (see also Appendix 13-A). This provides a "sea wing" independent of bad flying weather in this area, and provides coverage at a lower annual cost per thousand miles of barrier. Note should be taken that this permits certain changes in the position of the Pacific AEW barrier. Three of the proposed 8 stations fall on existing military bases in the area. The selected locations (shown in Fig. 13-2) are: Moffet, Korovin, Yunaska, Nikolski, Ft. Glenn, Gilbert, Ft. Randall, and Stepovak.

Western Alaska Gap Fillers:– To improve the low-altitude detection of the AAC radar chain from Kodiak to Cape Lisburne, 6 gap-filler scanning radars and one Fluttar (only) station (at Chefornak) should be added to the existing system. (For details of sites, see Appendix 13-B.) It is understood that the AAC has requested additional coverage, although sites have not been made firm. The proposed locations below (see Fig. 13-2) give solid cover to the coast from the Aleutian chain to Cape Lisburne, the western terminus of the DEW Line. The locations proposed are: Kwillingok, Cape Vancouver, Tisak, Kividlow, Tikizat, Sepping, and Chefornak (Fluttar only).

Cape Dyer-Greenland:– To close the line from Cape Dyer (eastern terminus of the DEW Line) across the Davis Strait, a station must be established at Holsteinborg

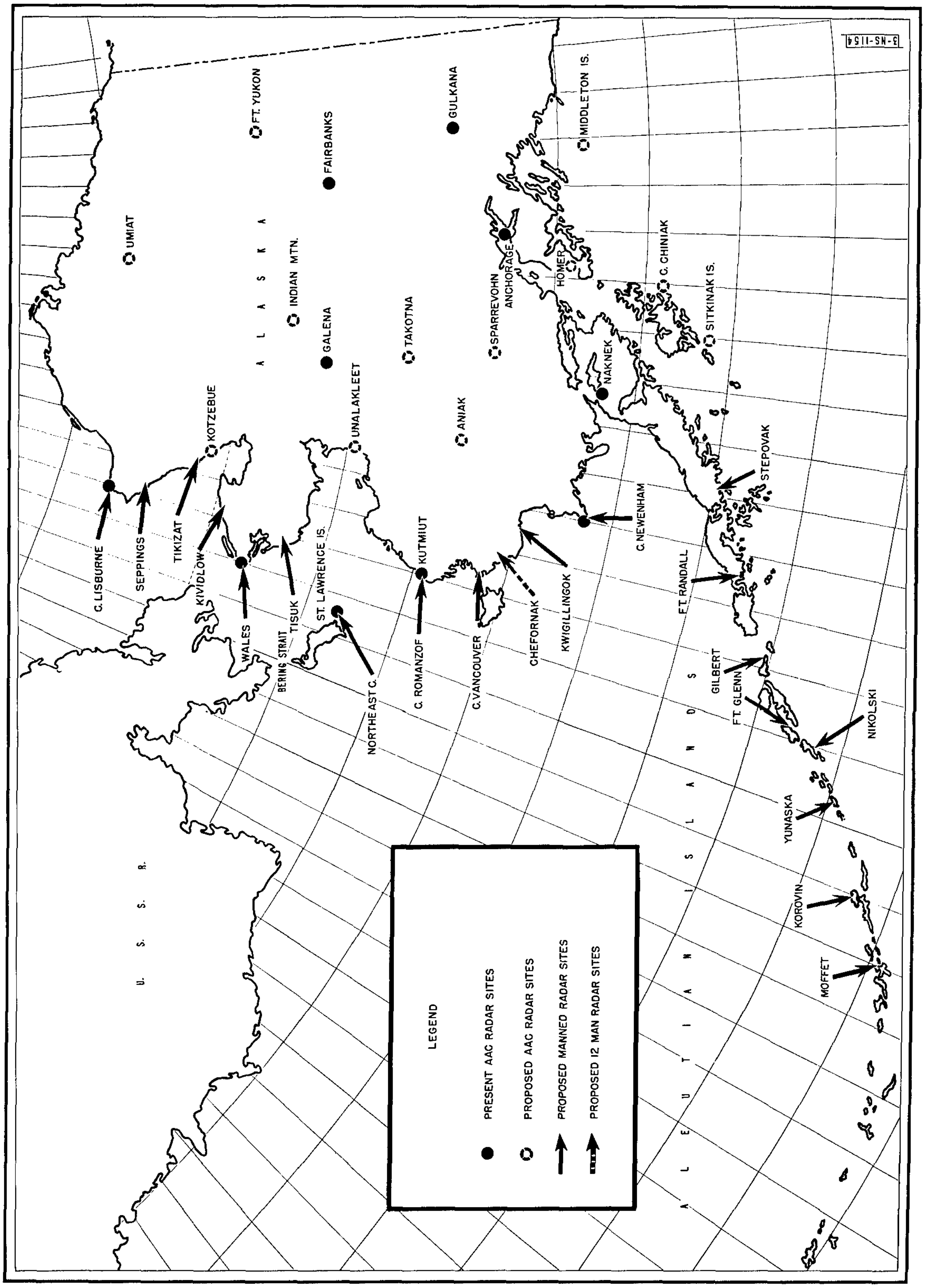


Fig. 13-2. Proposed prime radar sites and gap-filler sites in Western Alaska and the Aleutians.

(Greenland). Even if all advantage is taken of available height of land, a tunnel about 1000 feet high exists in the Davis Strait. This will require a picket ship as a plug during the 9 to 12 months of the year during which a ship can be maintained on-station (see Fig. 13-3). At other times, AEW patrols, even if intermittent, must close this gap. Long Fluttar links for this hole should be explored (see also Appendix 13-C).

Greenland Ice Cap:— A station is needed in King Christian IX Land (east Greenland) to close the Denmark Strait. Between this station, which can be on rock outcrop, and the station on rock at Holsteinborg, a total of 4 manned stations on the ice-cap will give low cover to a height of approximately 500 feet (see Fig. 13-3). It is conceivable that this "tunnel" can be closed with Fluttar radar, but the 500-foot terrain clearance at elevations of 7000 to 9000 feet, combined with general bad visibility, provides a very secure barrier in any case.

Iceland:— Four radar station sites have been surveyed; it is understood that 4 stations in Iceland have been requested by CONAD from the Air Staff. We believe that these are needed. The location chosen for the northwestern station, when combined with the Greenland radars, gives complete radar observation in the Denmark Strait. Radars with satisfactory range and reliability should be provided (see Fig. 13-3).

Faeroes to United Kingdom:— To close the barrier eastward, we see the need for one picket ship between Iceland and the Faeroes, and at least one radar station in the Faeroes (see Fig. 13-3). Steps should be taken to secure the erection of such stations. The data from these and from the Scandinavian radars should be available to CONAD. East of the Faeroes, the problem is not difficult but appears to fall into the territory of the NATO countries. It is understood that one radar, British Type 80, is programmed for installation in the Shetland Islands.

Redeploy AEW:— The above steps permit making advantageous changes in the AEW aircraft deployment. To avoid the undesirable condition of operation in the Kodiak area, to provide more warning time, and to reduce the number of aircraft required, AEW planes could be scheduled to operate out of Midway to fly to Adak and back non-stop. It is also possible to fly from Honshu (Japan) to the Aleutians and return non-stop. In the latter case, 4 more Aleutian radar sites should be planned to carry the land chain to Atka (see Fig. 13-3).

It may be argued that the Midway line can be avoided by an end-run, as can the Hawaii line. To reduce this threat, a looped AEW patrol line out of Midway may be run southwest — as far as necessary — for example, to Wake Island, 1000 miles southwest

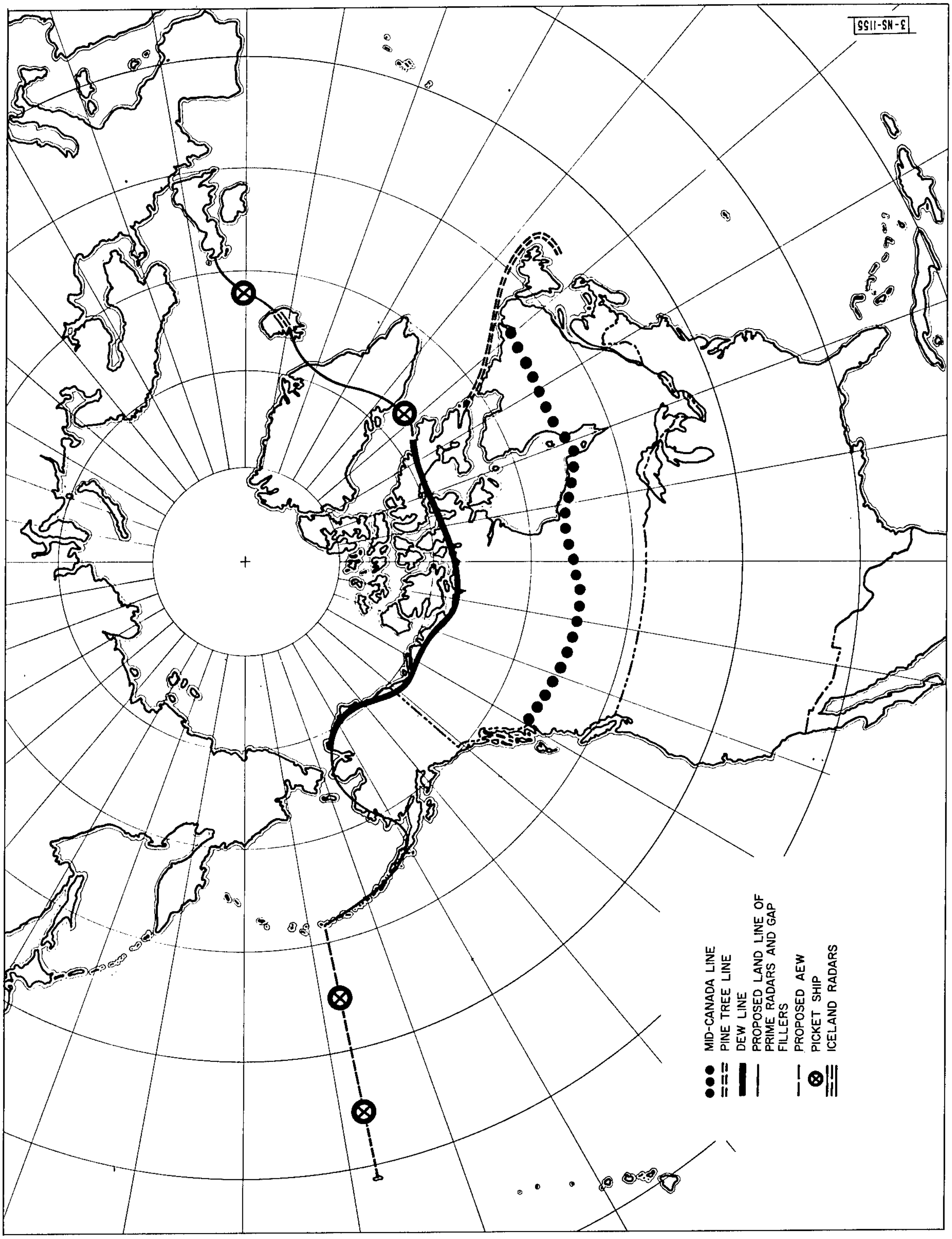


Fig. 13-3. Proposed extension of remote information barriers.

of Midway. An increase of 140 miles in strike route is engendered by each 100 miles of AEW patrol or of extra radar range.

The Japan line gives maximum warning time. It cannot be outflanked, and it gives maximum information about Soviet activities over water in the western Pacific. However, its closeness to Soviet bases might make spoofing attractive.

The advantages of the Midway line are its shortness, its better weather, the difficulty of outflanking it, and its lower susceptibility to continuous spoofing.

Disadvantage of the Midway line is congestion at the Midway base which might be alleviated by basing AEW aircraft at Hawaii and using Midway as a staging base. Plans of other military agencies for the use of Midway may compete for the available space. In view of the advantages of the Adak-Midway barrier, the use of Midway should be carefully weighed.

Disadvantages of the Hawaii line are its length and the poor terminal weather in Alaska.

On balance, it appears that, given enough aircraft to run a 2100-mile barrier, the barrier to be flown should be the Midway line. Aircraft released due to the shorter line could be employed in several useful ways. Weather permitting, the aircraft could be sent on up into the Bering Sea, or down to Japan, or used for extending contiguous cover.

In the Atlantic, the Argentia-Baffin Island-Azores AEW barrier will no longer be needed. However it will still be necessary to mount a patrol in the Davis Strait, but the majority of the AEW aircraft can be employed elsewhere, perhaps on a close-in AEW barrier patrol from Argentia to Bermuda or the Bahamas.

The Far Period 1960-1965:— In the period after 1960, very few additions to the remote information barriers seem necessary. Those added are planned to provide information required in the fighting system (see p. 13-36 *et seq.*).

To provide earlier information on high-altitude penetrations through the area north of Hudson Bay, it is recommended that 4 alarm radars of the Sentinel type be installed, one each at the Joint Canadian — U. S. Weather Stations as follows:

Mould Bay	(Prince Patrick)
Isachsen	(Elef Ringnes Land)
Eureka	(Ellesmere Island)
Alert	(Ellesmere Island)

These provide optimum high-altitude coverage from the DEW Line at Cape Parry to northern Greenland (see Fig. 13-4 and discussion in Appendix 13-D).

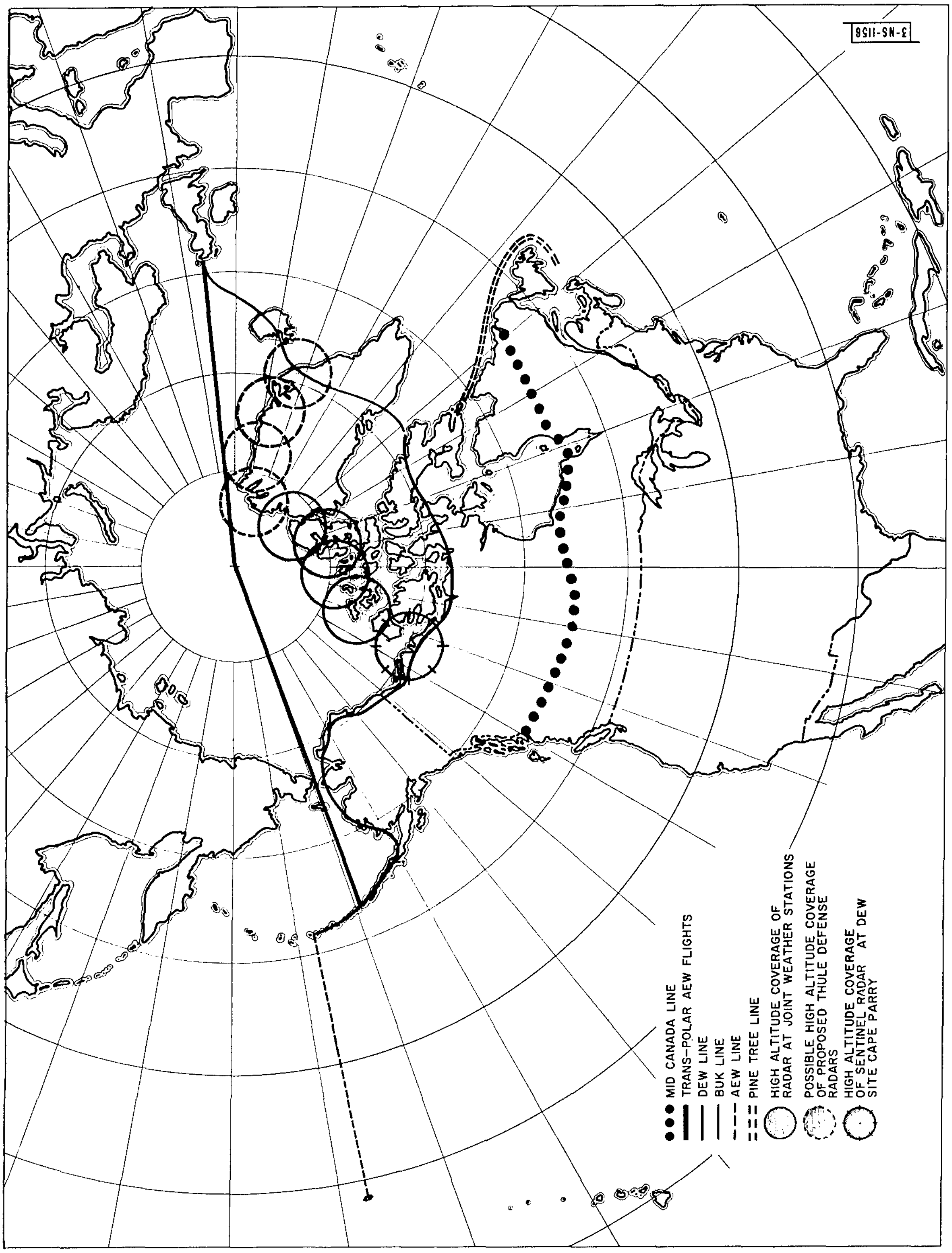


Fig. 13-4. Proposed addition to information system after 1960.

It should be noted that such additional warning does not become essential to the interception system until approximately 1960. However, these 4 stations can be set up at low cost and could be working in 1957 or 1958. Since it is expected that many existing services at the weather stations could be utilized, the establishment of radar stations would entail, per site, approximately two additional men, one Sentinel radar, some communication equipment, and one additional diesel engine (15 to 20 kw). It is felt that these warning elements could and should be provided in advance of other 1960 items.

Additional radar stations for early warning to Thule AFB have been suggested by SAC. It is understood that negotiations for permission to establish such stations have been sought by North East Air Command (NEAC) from the Danish authorities. We endorse the establishment of such stations in the area of Hall Land through Peary Land to King Frederick VIII Land. If these stations extend to 72°N on the east Greenland coast, an additional complete barrier from Cape Parry to Iceland is secured.

To provide information that will permit interception in the remote zone, AEW aircraft should be deployed to provide a barrier from the Aleutians north to the Pole, thence to northern Scotland (see Fig. 13-4). In advance of mounting such a complete barrier, a smaller number of AEW aircraft could furnish valuable data in conjunction with the land lines by providing coverage in the Bering Sea, the Beaufort Sea, and Greenland Sea.

Barrier Costs:– Based on the experience of Project Corrode and the estimates for the DEW Line, we may summarize the estimated initial costs and annual operating expenses of the barriers proposed in the foregoing sections as tabulated on the following page.

General Surveillance

General surveillance in the Remote Zone provides information of a different character from that provided by the more or less thin warning lines discussed in the preceding sections. In what follows, it is assumed that the need for warning lines has been recognized, that warning-line programs will be implemented, and that a system of general surveillance can be superimposed where feasible upon the communications systems provided for the warning lines.

In certain more or less isolated areas, relatively intense surveillance systems are now in being, as in Europe, Iceland, near Thule, Alaska, and Japan. In the ocean areas and in certain inhabited land areas, a less intense but nonetheless valuable

	Installed Cost	Annual Operating Cost
Aleutian Ground-Based Line		
8 stations @ $5 million	$ 40 million	
16% annual cost		$ 6.4 million
Alaskan West Coast		
7 stations @ $5 million	35 million	
10% annual cost		3.5 million
Greenland		
6 stations @ $6 million	36 million	
30% annual cost		10.8 million
Iceland and Faeroes		
5 stations @ $4 million	20 million	
15% annual cost		3.0 million
Joint Weather Stations		
4 Sentinel radars @ $2 million	8 million	
25% annual cost		2.0 million
SAC Defense Radars – Northern Greenland (NEAC now discusses 4 in Greenland)		
4 stations @ $6 million	24 million	
30% annual cost		7.2 million
Total Installed Cost	$163 million	
Annual Operating Cost		$32.9 million

Other Necessary Elements Not Priced

a. Argentia-Azores AEW Barrier using WV-2 aircraft and one picket-vessel station

b. Kodiak-Hawaii AEW Barrier using WV-2 aircraft and 2 picket-vessel stations

c. Replacing (b) above after 1957

Midway-Adak AEW Barrier using WV-2 aircraft and one picket-vessel station

form of surveillance is readily available at a low cost where aircraft will not be watched continuously but only observed occasionally during flight. So many data sources can be used that to avoid them all would be highly difficult and expensive of fuel and time. Many of these data sources will be moving, so that advance planning of circuitous, evasive routes would not be possible. It may be that certain very round-about long-distance strike routes cannot be blocked by warning lines until some high probability of detection that the enemy may well choose not to use them since they high probability of detection that the enemy may well coose not to use them since they offer him little or no advantage in the absence of complete tactical surprise.

Advantages of General Surveillance:– It is perhaps useful at this point to reiterate what was stated earlier, that general surveillance in the Remote Zone can provide crude tracking information which may:

> Strengthen, elaborate, confirm, continue, possibly anticipate, or even allow neglecting with safety, the information given by the warning lines.
>
> Show the development of hostile penetrations into recognizable force patterns and allow the air defense commander to deploy his defensive forces in a more efficient manner.
>
> Ease the problems associated with the identification of friendly aircraft entering contiguous cover.
>
> Make it possible to intercept suspected hostile penetrations for identification and possible engagement near or even outside the fringe of contiguous cover.
>
> In certain areas, for a limited time, be able to form a trustworthy replacement for a disabled section of a warning line.
>
> Be such a valuable aid to search and rescue operations, both on land and sea, that its cost may be justified for this reason alone.

Certain other advantages are to be found stemming from the organizing of shipping and the improving of communications. These include the provision of navigational information to friendly aircraft over both land and sea, increased safety of life at sea due to more exact knowledge of the whereabouts of ships and aircraft, the possibility of deriving automatic collision warning from air-search radars, and the existence of a readymade organization for control of shipping in the event of war. The additional communications recommended in northern Canada should be advantageous in civilian life.

Means and Problems:– Means are at hand to provide a general surveillance in parts, at least, of the region between the DEW lines and the contiguous cover zone at a cost

that is insignificant compared to the cost of complete surveillance – and that is even less than the cost of the tight surveillance provided in limited areas by DEW lines. Friendly shipping at sea and a Ground Observer Corps (GOC) in land areas serve as data-originating sources. Both types of sources need radar aids and possibly passive detectors. The main problems are those of organization and communication, and these problems appear soluble due to the presence of DEW lines, the fringes of contiguous cover, certain U. S. bases and the Ocean Station Vessels, now organized under the International Civil Aviation Organization (ICAO).

General Surveillance at Sea:– In all ocean areas, and in particular in the critical North Atlantic and Pacific Oceans, friendly naval vessels and merchant shipping provide the basis for a general surveillance radar system that offers high effectiveness at relatively low cost. This system is available today, requiring only some organizing to make it useful; it could increase in value as more and more ships can be fitted with air-search radars, preferably of the automatic-alerting variety.

Distribution of Ocean Shipping:– The ocean areas adjacent to North America and south of 50°N are at all times well populated with ships. Although Lloyds Register lists over 31,000 ships of more than 100 tons gross, it is estimated that an effective general surveillance system can be based on 2500 to 3000 larger ocean vessels – roughly, half American and half British with some NATO and Japanese vessels being added – which consistently travel across critical areas. Of this number of ships, roughly one-third may be expected to be in the area of greatest interest at any one time, the remainder being in port, or in coastal waters, or in more southern areas. Perhaps the most useful vessels will be Naval Combatant Units and Auxiliaries, including military Sea Transport Service ships, which can to some extent be controlled to increase the density of shipping in certain areas and of which many are already fitted with radars having some air-search capability.

In the North Atlantic, the ocean traffic is spread out in a wide band of fairly constant density extending up to the 50th parallel as shown in Fig. 13-5 which refers to 1 May 1952. Later in the summer, this band spreads slightly to the north. Including the very dense shipping near the coasts, some 3000 ships are shown, while, in the more interesting mid-ocean area between 35°N and 50°N, there are some 500 ships including 110 U.S., 160 British, and 260 other NATO ships.

In the Pacific, a somewhat smaller volume of shipping is indicated but, as shown in Fig. 13-6, it is interestingly concentrated in two lanes across the North Pacific and a third lane down the coast of Mexico towards Panama. This chart refers to

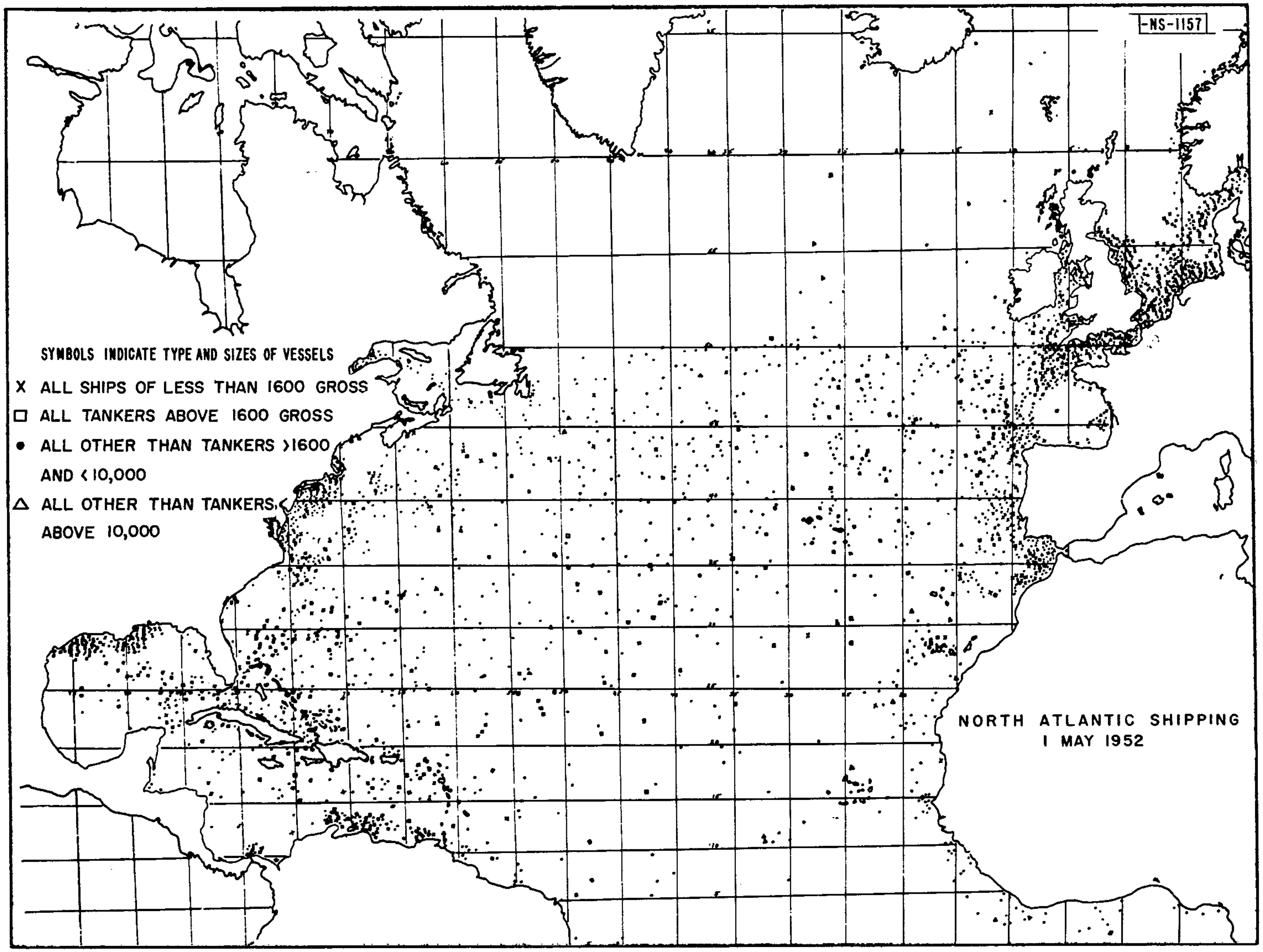


Fig. 13-5. North Atlantic shipping.

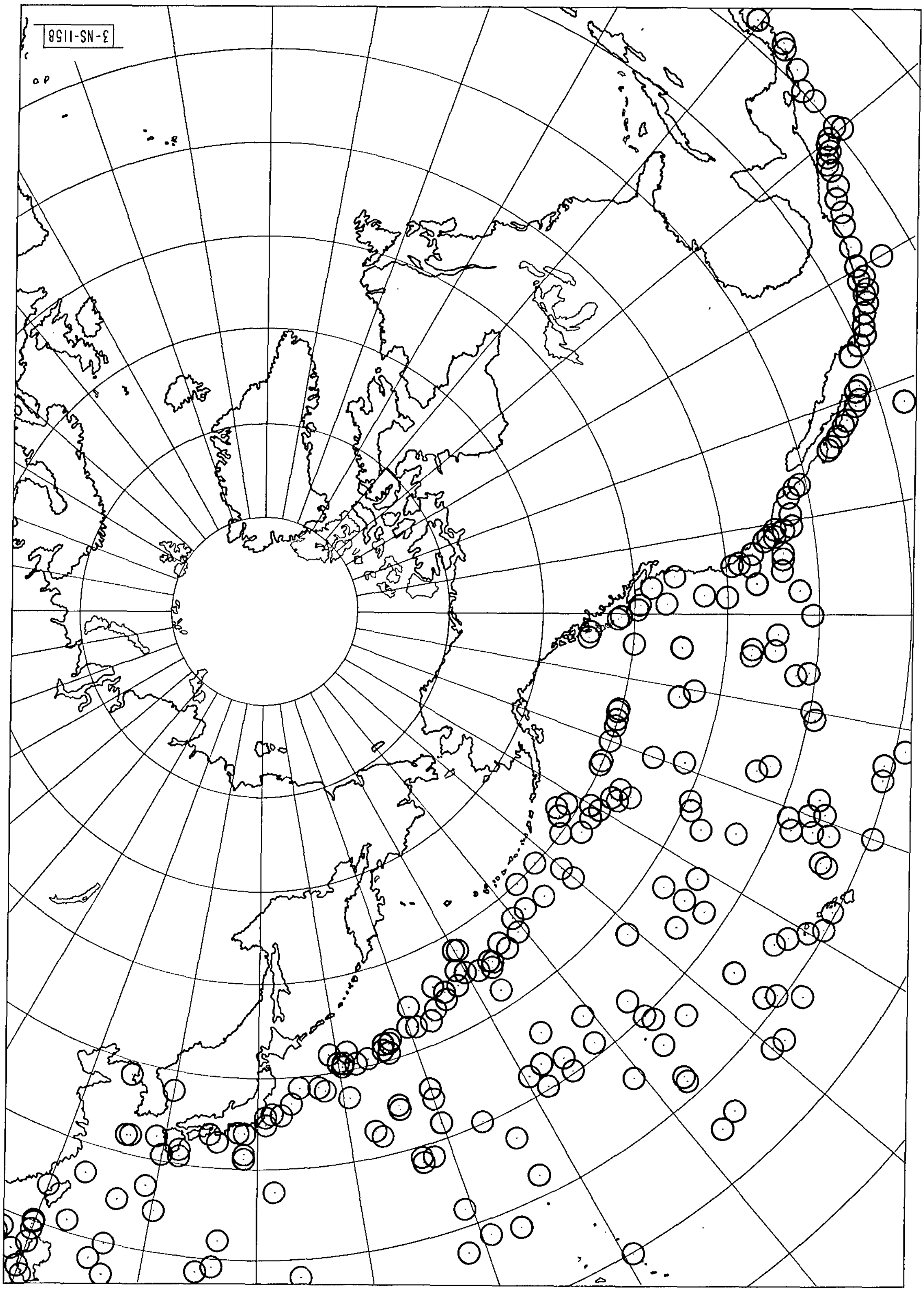


Fig. 13-6. Pacific shipping, 15 November 1954. (circles show coverage of 75-mile radar)

15 November 1954. The trans-Pacific lanes of shipping lie across strike routes coming out of Siberia and avoiding an Alaskan-Aleutian surveillance system. The lane to Panama offers another block against long circuitous flight routes south of Hawaii or Midway. Some 200 ships are shown beyond the limits of coastal waters, of which 129 are USN or U.S. registry, 34 Japanese, and 18 British. Again, the factor of about three to account for ships in port or coastal waters or in less interesting areas is applicable.

Communications and Organization:– The transmission of reports from merchant vessels should probably go first to filter centers on the Ocean Station Vessels and convenient island naval bases. As shown in Fig. 13-7 the distances involved in the Atlantic will rarely exceed 300 miles, and ordinary high-frequency (HF) ground-wave in the 1.6 to 3.5 Mcps band ought to be adequate at all times. One more Ocean Station Vessel to replace one recently withdrawn might be advisable. In the Pacific, two more such floating filter centers might be needed. Voice transmission would probably be satisfactory most of the time, key all the time. Some arrangements with the Maritime Radio Operator's Union might be necessary to allow Deck Officers to use the equipment when the operator was off-duty. Communications, then, will present no serious problems in the ocean areas.

From the Ocean Station Vessels, the transmission of reports of unidentified vessels and, as required, of identified vessels can be carried out by various means as, for example, by high-power HF to the Coast Guard Station Radio Washington and by land line to CONAD and CINCLANT as is done today for unidentified aircraft seen by radar or visually by the Ocean Station Vessels themselves. Later, when contiguous cover extends seawards or sea-wing barriers are in place, it may be desirable to route any reports directly to one or other of these groups to be forwarded by their channels. Any suitably placed picket ships associated with such systems probably should be used as filter centers. The organization of the general surveillance must be such that it can be altered from time to time in order to meet most rapidly any demands placed on it by the commander responsible for the area in which it is operating.

Under Operation Skywatch, the U.S. Navy, in conjunction with the U.S. Air Force and the U.S. Coast Guard have been organizing coastal shipping to report visual aircraft sightings to the nearest shore filter center through the Marine Radio Telephone System. In the light of this experience, it is recommended that the appropriate naval commands commence the selection and enrollment of various categories of ships into an ocean-wide reporting system, bearing in mind the probable later addition of air-search

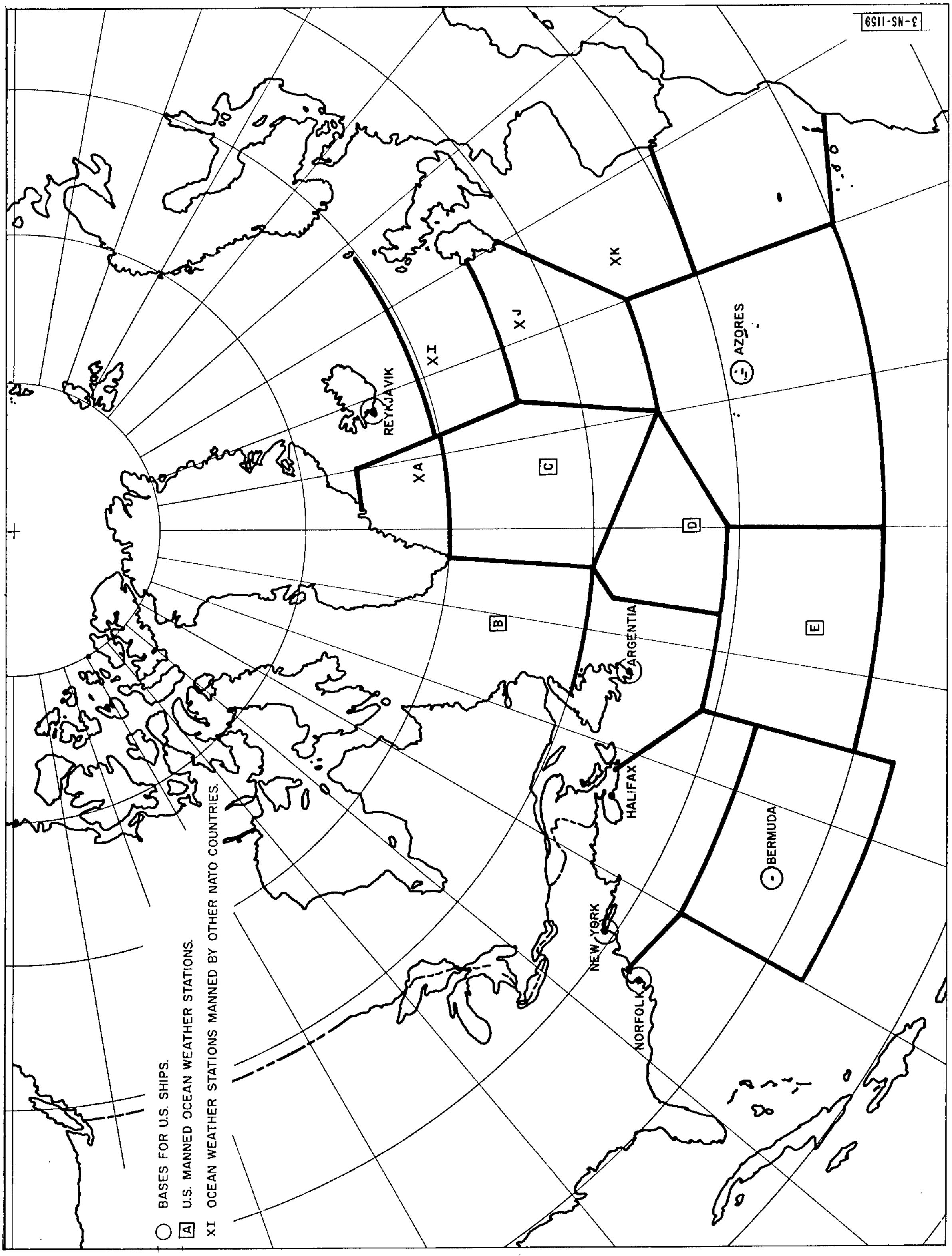


Fig. 13-7. Proposed communications organization for North Atlantic general surveillance.

radars. At the same time, British and Canadian authorities should be approached for assistance in enroling ships of their flags in a combined scheme. A more careful study of shipping distributions will rapidly reveal the extent to which NATO, Panamanian, and Japanese shipping will have to be enrolled in the early stages.

Reporting from ships could be reinforced by installation of radars, and in some cases communication facilities, on advantageously situated islands such as Sable, Wake, Midway, Bermuda, the Azores, etc.

Radars:– At the moment, there is no completely satisfactory radar for fitting on merchant vessels as an automatic-alerting air-search radar. The AN/TPS-ID can be modified by adding automatic-alert features and omitting MTI, and some of these should be fitted. This can be done in a relatively short time at an estimated cost of $30,000 per ship and maintained on a voyage-end basis at an estimated cost of $ 2,700 per year. A modified version of the SRa* is another possibility.

It is apparent, however, that the bulk of the fittings ought to be of a specifically designed radar adapted from the Sentinel type of ground-based radar. For certain smaller classes of vessels, a similarly specifically designed small radar of the Super-Chipmunk variety would be useful. Thus a family of two or perhaps three radars should be developed for the ocean general surveillance role. The smallest might have a range of 20 miles, the second a range of 60 miles, and the third for large ships could have an extra-large antenna and a range of 90 to 100 miles. The first two are the important ones for the bulk of the fittings; the third (larger) set might never be fitted on cargo vessels but only on Naval Auxiliaries and fast passenger ships (see Appendices 4-C, 4-D, and 13-E).

Capabilities

Atlantic:– In the Atlantic, the density of ships is sufficiently constant that statistical methods can be employed to find the cumulative probability of getting one or, say, three reports on the aircraft flying towards the U. S. coast from a point south of Greenland on the 50th parallel. Figure 13-8 shows the result of a sample computation. (See Appendix 13-F for further discussion of detection capabilities.) If all the 500 ships in mid-ocean were equipped with a 30-mile radar, we should have, approximately, a 90 per cent probability of getting 3 or more reported sightings during the first 400 miles of such a flight. If only one-third of the ships were so equipped or if the ships had only a 10-mile radar, we would not get this probability until 800 miles

*SRa is the designation for an air-search radar developed for installation in destroyers.

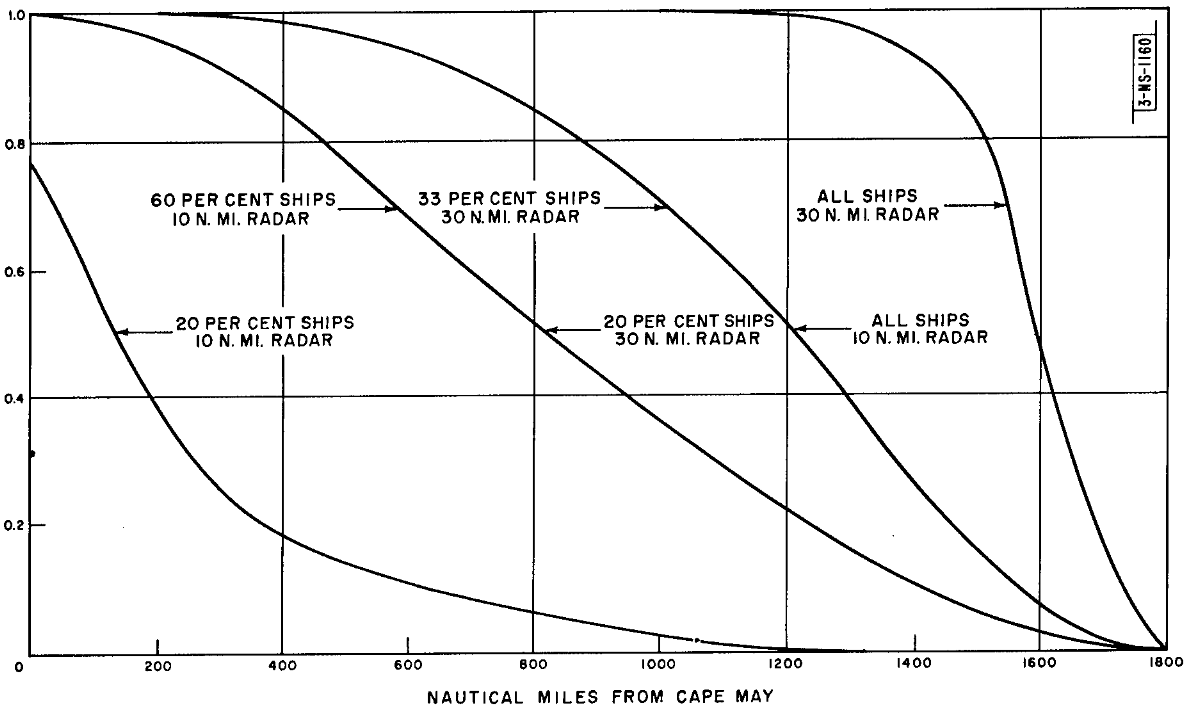


Fig. 13-8. Cumulative probability of three or more reports.

had been traveled but we would still have a 90 per cent chance of one or more reports in the first 400 miles (not shown). These curves and those for very few ships fitted with very short-range radars all rise to high levels of probability near the coast where the shipping is denser but where the time-to-go is very low. It should be pointed out that where the density of ships is relatively constant we would again have a 90 per cent chance of getting three or more reports in the second 400 miles or in any 400-mile stretch for all ships fitted with 30-mile radars.

Pacific:— Due to the interesting lane-type distribution of shipping in the Pacific, it is preferable to examine the situation graphically and to quote some results, rather than to present a possibly misleading curve such as is valid for the Atlantic. Since the shipping pattern is shifting, it is valid to average over several parallel flight paths in each case. This was done for plots of ship positions for May 1952 and November 1954. Six randomly directed paths from Petropavlovsk were plotted and examined over the first 1500 miles. With a 60-mile radar on all ships in the area, one would expect 4 reports in this distance on both days and, with a 30-mile radar, 2 reports. Flights from Sakhalin were similarly examined and gave essentially the same results. Another series of checks was made on four arbitrary paths from each of these two points to the West Coast including one route south of Midway. Detailed figures are given in Appendix 13-F, and averages only are quoted here, the spread over all the routes being about 3 to 1 in 1952 and 2 to 1 in 1954. West of 150°W (Hawaii) one would expect 6 reports from 60-mile radars in 1952, and a further 4 reports between 150°W and 100 miles off the coast, or a total of 10 reports on the whole route. The figures for 1954 are 6 and 3, totaling 9. For 30-mile radars the figures are 3 and 2, totaling 5 in 1952 and 3 and 1, totaling 4 in 1954. It is apparent that on such long flights little tracking information is available, but that there is a high probability of several reports en route. The 4 or 5 expected reports from 30-mile radars correspond to the lower-altitude case (about 400 feet) rather than the 9 or 10 reports from 60-mile radars (about 2000 feet). The enhanced capability of the longer-range radar is evidently important in the Pacific.

Extensions:— Other means exist for extending ocean general surveillance. It is obvious, for one example, that Panama-bound ships in the Pacific, radar-fitted to play their part in general surveillance, will appear in the Caribbean, or Gulf of Mexico. It will be advantageous to provide reporting points in these areas and it may prove advantageous to increase deliberately the density of radar-equipped ships in these southern approaches to North America. Such a program is, of course, of less immediate interest than that in the more northerly areas.

In certain highly critical areas such as off Newfoundland, Nova Scotia, and New England, the concentration of fishing vessels is such as to provide a highly valuable low-altitude detection system. The plans of the Navy for offshore reporting systems similar to Operation Skywatch should be extended to these areas, and small radars of the Super-Chipmunk class should be provided for the fishing vessels. In addition to voice radio and Loran equipment, a surprising number of fishing vessels already possess surface navigation radars (50 per cent of those on Georges Bank and 15 per cent of those on the Grand Banks).

Quiet Zones:– In coastal waters, it is apparent that the number of reports from ships may become so large as to clutter up valuable communication channels. When military contiguous cover is effective, quiet zones ought to be declared and merchant vessels should possibly be requested to report only obvious low flyers. Experience with an operating system will easily show the correct action to be taken.

Costs:– It is difficult to arrive at the costs of general surveillance in the ocean areas since our limited information does not allow a prediction of the efficiency with which the program can be set up in the Atlantic or of the inefficiency that will have to be tolerated in the Pacific. ("Efficiency" here refers to the fraction of time that chosen ships spend in the ocean areas of interest.) If one takes the previously quoted estimate of 2500 to 3000 ships enrolled in the scheme and also the firmer estimate of $30,000 for the installed cost of a radar of TPS-1D class, it is apparent that the capital expenditure would reach a value of $75,000,000 to $90,000,000 spread over two or more years. A total annual operating cost of $10,000,000 might be a reasonable estimate. Should either or both figures be in error by a factor of 2, the system would still be relatively cheap compared to the methods required in the contiguous cover zone or even to a barrier patrol of AEW and picket ships. (See also Appendix 13-G.)

General Surveillance in Northern Canada:– The situation on land is very different from the situation at sea. No mobile data platforms are available and hence the great virtues of an upredictably shifting system are unavailable. The density of populated centers in Northern Canada between the Mid-Canada Line (55°N) and the DEW Line (70°N) is on the average about the same as that of shipping in the mid-Atlantic, but in certain areas it is too low to have any real significance. A Ground Observer Corps organized by the Royal Canadian Air Force (RCAF) exists in this area, along the Alcan Highway and the MacKenzie River. The distribution of the GOC is sufficiently dense to have a considerable value, particularly if it is radar-aided, perhaps with the Super-Chipmunk. A further difficulty in this area is that, during auroral or

ionospheric disturbances, the reliability of communications is in doubt since HF ground-wave ranges are seriously limited by poor ground conductivity. It is worthy of note that the GOC has been organized through or on existing communications networks provided by the Department of Transport, the Royal Canadian Corps of Signals, the Hudson's Bay Company,* Canadian Pacific Airlines, and other civilian and governmental bodies.

A Possible System:– Recognizing that a gap of about 900 miles exists between the Mid-Canada and DEW lines, the RCAF has proposed, and Lamp Light concurs, the provision of high-altitude cover from a few high-power radars. Lower-altitude cover is impractically expensive, but it appears that a minimum of one report can be obtained on strikes through this area by taking every possible advantage of present and programmed military and civilian installations in this area. All military posts and all airfields ought to be fitted with radars of a 60- to 100-mile automatic-alerting capability. A few other settlements might be similarly fitted, but here the provision of extra military or civil service personnel would be necessary, as contrasted to present or planned military posts where no more than one or two extra men should be allowed. At the same time, a program of supplying Super-Chipmunk radars to other suitable GOC posts should be carried out. (For further discussion see Appendix 13-E.)

Capabilities of Possible System:– An arrangement such as has been described above has been planned in rough detail with the result shown in Fig. 13-9. A total of 32 localities for large radars is represented by circles of 75-mile radius. Of these 32, about 5 might be called "invented" sites requiring extra manning. The other 27 are either military posts or airfields where a minimum of extra manning would be necessary. At about 4 of these 32, special action will probably be advisable to secure greater low-altitude radar ranges, particularly at the top of Hudson Bay. The smaller 20-mile radius circles indicate 65 localities at which Super-Chipmunk might be installed. It is evident that, in the western portion, two or three reports ought to be available on all flights at altitudes of more than 1000 feet terrain clearance, while in the eastern portions one report should be given for flights above 2000 feet (or less on most routes). A large number (20) of Super-Chipmunks might be noticed just north of the Mid-Canada Line. These have been selected as representative locations where these radars can assist in shepherding "bush" flyers through the Mid-Canada Line as "pre-identifieds" since these locations are terminals for many bush flights.

*The Governors and Company of Gentlemen Adventurers Trading into Hudson's Bay.

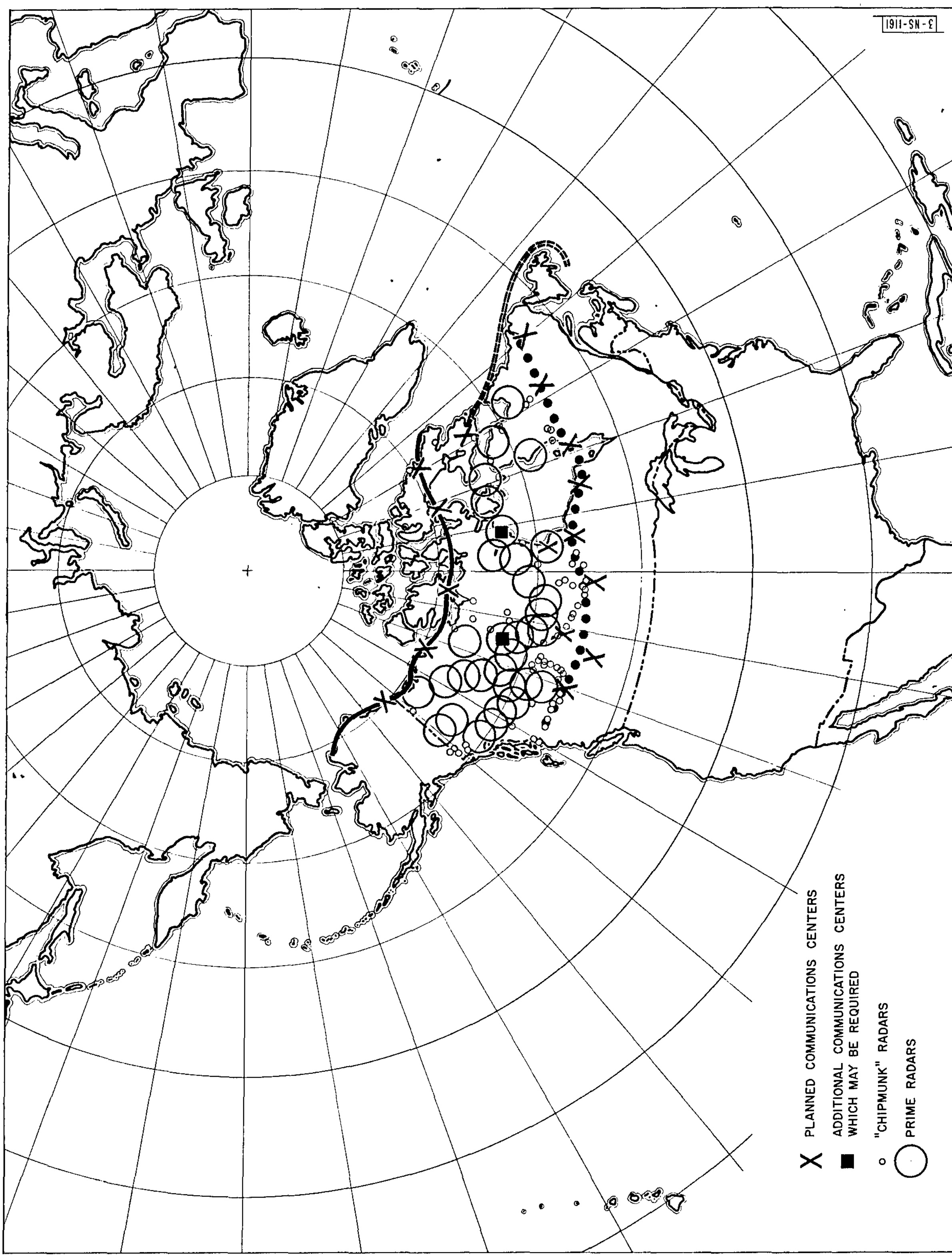


Fig. 13-9. General surveillance in Northern Canada.

Communications and Organization:— To overcome the communication problems of the north, it will be necessary to treat each reporting link as an individual case and apply such methods — tropospheric scatter, Janet, low frequencies — as appear most suitable in each case. The most important point, however, is to provide a 24-hour listening watch at the receiving ends of each link. To ensure this, it is proposed that means be provided for most stations to report directly to communications centers or relay points of the DEW and Mid-Canada Lines (these are marked with crosses on Fig. 13-9); it is evident that few stations will be more than 200 miles from a suitable center. The few that are farther away are mostly located on the MacKenzie River and are, in fact, posts of the highly reliable Royal Canadian Corps of Signals radio-telephone system. The provision of two extra reporting centers at Yellowknife and at Chesterfield Inlet (marked with squares) may prove advisable.

The organization of this system should be such that it can report directly to the air defense forces responsible for the Mid-Canada and DEW Lines, although the lines would act essentially as a relay system for the more northerly stations.

Radars:— For the minor or GOC posts, a Super Chipmunk radar appears ideal. For the larger posts, a coherent pulse-type radar based on the Sentinel design, but with a smaller antenna on a possibly higher frequency, requires development. A frequency shift from 600 Mcps to L-band would enhance the use of such a radar for auxiliary purposes such as transport aircraft control.

It appears unwise to consider putting the TPS-1D radar into the hands of relatively unskilled personnel in view of its tuning and maintenance problems. For the "special" locations and possibly others, a full-size Sentinel would be an excellent choice.

Costs:— Since this system is, again, a system that ought to grow as facilities can be exploited, it is difficult to establish cost figures. For small stations, we assume a cost of $10,000 per station, more than half of this amount covering extra communications and power. This should be a liberal allowance for Super Chipmunk radars, the installation of which we consider the equivalent of setting up a home television receiver – feasible, that is, wherever electric power is available and a small antenna can be erected. An average cost of $250,000 for each of the larger stations seems reasonable. Thus, for the possible system described above, a total cost of $8,500,000 is derived.

Extensions of General Surveillance:— Seaborne extensions of general surveillance have already been discussed. There are other land areas where principles outlined for the northern Canadian mainland may also be applicable. From the air defense

point of view, such areas might qualify only if they tie in more or less naturally with other surveillance areas. From the intelligence point of view, however, other places having peculiar geographical relations might also be of value; but in this case it seems certain that more refined methods of observation should be employed and that sporadic reports of aircraft activity should never be allowed to jeopardize the primary functions of such installations.

Hudson Bay:– Hudson Bay lies along favorable enemy strike routes and points deep into the heartland of North America. In summer, at least, it offers good radar landfalls, and at all seasons allows relatively easy low-level flying. Although no closer to the heartland than, say, Newfoundland, it is apparent that special action ought to be taken to provide coverage in this area. During the open-water season, ships and AEW aircraft could provide adequate surveillance; during the winter, temporary stations might be placed on the ice; if UHF-equipped AEW aircraft can operate satisfactorily over ice, they could be used the year around. To allow a conventional ship to be frozen in an ice pack is not usually regarded as very wise, but it appears certain that a specially shaped and strengthened hull could be repeatedly frozen in with little expectation of damage. The appropriate Canadian authorities should be requested to join in a cooperative program which might lead to the provision of two or three such vessels for year-round operation in Hudson Bay and one or two for Davis Strait. Other possible uses would be in the Great Lakes and in the Beaufort Sea.

The Canadian Archipelago and Thule:– Some four or five Chipmunk stations north of the DEW Line are shown in Fig. 13-9 and these might prove useful in identifying and controling friendly aircraft. The addition of Sentinel radars and one or two men to the arctic Weather Stations – Mould Bay, Isachsen, Eureka, Alert – together with the radars along the northern edge of Greenland planned for the local defense of Thule, would provide a useful high-altitude bulge to the DEW line. Such a group of stations would be of particular value in conjunction with possible trans-polar AEW flights on a random timing basis.

Alaska and the Bering Sea:– Super Chipmunk radars in a GOC net could provide a valuable and necessary addition to the abilities of the Alaskan Air Command. In conjunction with possible random AEW flights in the Bering Sea, the installation of larger radars on the Pribilofs and St. Matthew Island should be considered.

Southern Greenland:– Although isolated from the general surveillance system of Canada and the North Atlantic, southern Greenland lies across the flight paths of many friendly aircraft and across a possible enemy strike route. About a dozen

localities — airfields, weather stations, communication stations, naval bases — are available south of the Arctic Circle where Sentinel radars could profitably be installed; they could assist in the handling of westbound flights, providing not only identification but also navigational assistance. It is suggested that NEAC should be requested to examine these possibilities in conjunction with the Danish authorities and with ICAO.

The Norwegian Sea:— In connection with the local defense of Thule and as means of providing assistance to civilian flying in the area, larger radars on Jan Mayen, Bear Island and at one or two locations on Spitzbergen, would be of use. It is conceivable that arrangements for these might be made through Scandinavian Air Lines and ICAO. Jan Mayen is a special case of more interest in sea traffic control; but, if this island is exploited for this purpose, a large radar may well be necessary for local warning and control.

The ANDB Beacon:— It is anticipated that the Air Navigation Development Board (ANDB) Beacon, which operates similarly to the Mark X IFF, will be fitted to many if not all civil airlines operating in or into the United States. Ten distinctive codes are provided. By exploiting the essentially line-of-sight capabilities of this beacon, friendly traffic from Europe can be kept under observation for well over 75 per cent of their routes by interrogations from land bases, the Ocean Station Vessels and a bare minimum of merchant and naval vessels. The easing of identification problems can readily be seen to be enormous. A word of warning, however, is necessary so that the possibilities of this beacon do not lead one to overlook the continuing need for primary radar surveillance to cope with non-beacon-carrying aircraft and low-altitude flights. An increase in the number of available codes to 62 is recommended and is believed to be simple, while a further increase to 400 or 1000 codes is desirable; the possibilities of achieving this should be explored.

Transport Aircraft and General Surveillance:— Reports of aircraft sightings made by friendly civil and military transport aircraft in ocean areas should be welcomed and provision made for relaying such reports through ICAO and other ground communication stations normally operating with transoceanic aircraft. Such reports are of especial value in the North Atlantic since flight paths frequently lie well to the north of shipping paths. The numbers involved are quite significant, as many as 60 per day on northern routes, corresponding to one for every 2.5° of longitude. Some military transport aircraft already carry radars; radars on civil transports for avoidance of bad weather and for navigational purposes are a distinct possibility, and such radars may have useful random low-altitude capabilities. It is recommended, also,

that the question of hiring civil transports to carry operating air-search radars on certain transoceanic flights be examined in detail as to costs, advantages and feasibility (see Appendix 13-H). One particular advantage of this practice would be that the enemy might be unable to tell by ferret methods whether certain signals were coming from a "low grade" civil radar or a "high grade" AEW aircraft. Another advantage would be radar "flooding" to force submarines to submerge to avoid possible detection. A method of carrying radar in transport aircraft, which has interesting possibilities, is the use of fixed or scanning antennas in the Lockheed "Speedpak". This boat-like structure clamps under the aircraft fuselage if carried, and only the display equipment and the operator need be inside the aircraft. The cost of operating an AEW patrol in this fashion would be a small fraction of the cost of a high-grade military barrier, and civil airlines might well welcome this type of subsidized payload.

RECOMMENDATIONS: REMOTE INFORMATION ZONE

Information Gathering: Barriers

1955–1958: We recommend extension of the DEW Line by using programed AEW aircraft and pickets on continuous patrol from Hawaii to Kodiak Island, and from Argentia to the Azores, with periodic patrols to close the gap from Cape Dyer to Cape Farewell.

To provide earlier information on high-altitude penetrations through the area north of Hudson Bay, we recommend that alarm radars of the Sentinel type be installed at the Joint Canadian-U. S. arctic Weather Stations.

1957–1960: To prevent end runs, to provide more warning time, and to improve low-altitude detection, we recommend:

Extension of the land barrier along the Aleutians to Adak.

Extension of the DEW coverage by gap fillers in the radar chain from Kodiak to Cape Lisburne.

A radar station at Holsteinborg (Greenland), and a picket ship in the Davis Strait.

Investigation of the possibility of closing the gap across the Davis Strait with long Fluttar links.

A radar station in King Christian IX Land (East Greenland) and four manned radar stations on the ice cap.

Four radar stations in Iceland.

At least one radar station in the Faeroes.

One picket ship between Iceland and the Faeroes.

Redeployment of AEW aircraft in the Atlantic as required for contiguous cover. In the Pacific, investigation of the feasibility of basing AEW aircraft on Midway to substitute a Midway-Adak line for the previous Hawaii-Kodiak line.

1960–1965: To provide information that will permit interception in the remote zone, we recommend AEW aircraft patrols from the Aleutians north to the Pole, thence to Northern Scotland.

We recommend the establishment of radar stations in Northern Greenland for the defense of Thule and for the completion of an additional complete barrier from Cape Parry to Iceland.

Information Gathering: General Surveillance

For the Ocean Areas, we recommend that ocean vessels be organized into a general surveillance system in the North Atlantic and Pacific Oceans as rapidly as possible. Subsidiary recommendations towards this end are:

That tests of the communications processes be initiated at once, and improvements undertaken where necessary.

That such radars as are available, both surface- and air-search types, be employed as soon as the system is organized.

That, as an interim measure, radars of the AN/TPS-1D and SRa types be installed in selected classes of ships.

That the development and installation of more suitable radars be carried out within 18 to 24 months.

That one U. S.-controlled Ocean Station Vessel be reactivated in the North Atlantic and two such be activated in the Pacific.

That radars and, in certain cases, communication centers be installed on such islands as Sable, Bermuda, Azores, Midway, Wake, etc., as parts of the ocean area general surveillance system.

That the fishing fleets operating well off the Northeast coast of North America be organized into a type of Ground Observer Corps using, where practical, radars of the Chipmunk type.

For the Land Areas, we recommend:

That the Canadian authorities be invited to consider the installation of a general surveillance system in Northern Canada, in a manner which will complement the DEW and Mid-Canada Lines, and plans for high-altitude radar cover.

That radars of low information rate and low manning requirements such as the Chipmunk, Super Chipmunk, and Sentinel, and a smaller antenna type of Sentinel, be further developed and exploited.

That further study be given to methods proposed for filling Hudson Bay, Davis Strait, and other water or pack ice gaps.

That the use of Chipmunk type radars in the Alaskan GOC be commenced.

That the principle of using all military and governmental outposts as radar data sources be further considered in possible extensions such as Greenland and the Bering Sea.

That the possible exploitation of military and commercial transport aircraft as radar data sources for general surveillance be further examined.

That the number of codes available on the ANDB beacon be increased to 62 and its use by all transoceanic traffic be encouraged.

THE REMOTE AIR BATTLE

The geographical position of the United States allows consideration of even more-distant combat operations than those described in Chap. 12. It appears quite possible to further enlarge the zone in which a remote air battle (RAB) might be fought, and this section will cover the weapon system, the techniques, and the tactical employment of a long-range interceptor aircraft that can be used to extend the combat zone beyond the range of close-control fighters, to a distance of some 2000 miles around the important target areas of the North American continent. This can be successfully achieved during the 1960-1965 time period.

It is clear that the air defenses of North America should be designed to force great losses on the enemy if he attacks. The very high attrition necessary can be achieved only by a complex of weapon systems, since no single air defense weapon system can by itself protect North America against the variety of offensive weapons potentially available to the enemy. More specifically, with respect to the remote air battle, there are many potential advantages in more distantly deployed weapon systems that will be lost to the defense if they go unexploited. Therefore, while at present it may seem to be more economic to build contiguous defenses, we should develop the capability for operations in the more remote areas. (This does not imply that we as yet know how to reach the best balance of strength between the inner and outer defenses.)

Several points, which apply to both the inner defense system and to the RAB system, require emphasis. We have used the same assumption about the area to be defended, and are trying to provide air defense for the North American heartland (plus other

areas) and for the Strategic Air Command. Provisions for an RAB capability in the 1960 time period will be discussed; we do not believe that this capability can be achieved any sooner. Also, the RAB system is conceived as a complement to the inner defenses, not a replacement. In other words, we agree with the concept of building our systems outward from the defended area and, in effect, adding an additional layer. Finally, in order to get some idea of the relative effectiveness of the suggested system, we shall make our estimates of quantities of weapons in terms of ADR 54-60 budget levels.

The Role of Remote Air Battle

Before detailing any specific weapon systems for RAB operation, it is first necessary to examine why we want this type of capability for our air defense. Studies of the capabilities of the inner defenses, estimates of the quantity and characteristics of the threat, and the estimated performance of weapons, must all be related before firm commitments and good choices can be made.

Certainly, one of the worst threats that could be directed against North America by 1960 would be a large, concentrated raid composed of perhaps one thousand T-37 or T-39 jet bomber aircraft flying in a zone some 50 by 250 miles. This raid might fly high or low, and might include decoys and electronic countermeasures. At a later date, perhaps by 1962 or 1963, the enemy might have a high-altitude cruise-type surface-to-surface missile like the Navaho which could fly intercontinental missions at about 75,000 feet at Mach 3. Also, since medium-range air-to-surface missiles (ASM) are possible threats in this time period, the ability to kill the missile-carrying aircraft would be an asset to the defense.

Estimates of the capabilities of the contiguous defenses to counter this massed bomber raid are mentioned in Chap. 12 on the inner defense system. It is the qualitative deficiencies of the inner defense zone that force the examination of the capabilities of the remote air battle system. Briefly, by adding an RAB capability, we are trying to provide for the air defense of North America:

> A real deterrent, by forcing the Soviet striking force to plan any attack in the face of a combat zone of great depth.
>
> More time and space to engage and kill massed raids.
>
> More information to improve the commitment and kill effectiveness of the inner defense.
>
> A change in timing of any massed raid (which will also improve the inner defense).

An area in which the defense can use atomic weapons of several types with rather complete tactical freedom.

Greater capability to combat decoy-launching and ASM-launching aircraft, ECM, and potential threats of improved performance (Navaho).

In summary, the over-all objectives of tactical flexibility and greater time and space for the defense are the most important features that any RAB system should provide.

Area of Operation of the Remote Battle

The ultimate distance from the defended area at which the RAB forces might operate is limited by the information sources and the basing of the interceptors. Details of methods to extend the fighting zone 1400 to 2000 miles from the continental United States and populated Canada are given in subsequent sections.

For the purposes of outlining the requirements on the RAB weapon system, it is necessary to note that the potential area of operation extends from the edge of the region of operation of the close-control fighters to the limits imposed by information sources and deployment. In general, this area extends over the Canadian arctic and sub-arctic wastes and over Atlantic and Pacific ocean areas. In particular, it may operate in areas where there exist little or no current data on the position of enemy forces, a condition that has distinct implications concerning the information-gathering potential and the weapon system.

Requirements for an RAB Weapon System

The weapon system developed for RAB operations should, if possible, be designed to operate efficiently in the Canadian arctic and over the oceanic areas just described. It should be capable of performing the following missions against high- and low-flying manned bomber targets and against cruise missiles of the Navaho type (high-altitude only):

Interception without the aid of a close-control system, on alarm from any distant information source.

Transmission of information back to CONAD, for aid in the efficient commitment of additional forces for both the RAB and the inner defense weapon systems.

Armed patrol, including the occasional arming of AEW radar barriers, primarily for advanced alert in the event of strategic warning.

The same aircraft, radar system and weapons should be able to perform all three of the above missions. In fact, whether intercepting on alarm from an early-information line, or flying on armed patrol, the transmission of information back to CONAD should be a simultaneous mission requirement.

The system that should be developed must have a long useful life with the major effort being put into radar and weapon development. Since manned high-performance interceptors cannot be expected to keep abreast of the bomber threat, a long-range air-to-air missile must be developed to close the gap between the performance of present interceptor types and that of the expected bombers. Such missiles must be able to attack targets at high and low altitude when launched from the cruise altitude of the interceptor. With this type of weapon capability, the interceptor's performance does not have to be superior to that of the target. As will be shown later in this section, however, there may be a pay-off in developing a very large, high-speed interceptor. This need has been recognized by the Air Force to the extent of the recent long-range interceptor competition.

Consistent with the philosophy of placing the burden of successful operation on the radar and weapons, characteristics of a weapon system to carry out the missions above are:

> A search-radar system with a detection range of about 200 miles. To enhance information-gathering and re-attack capability, a look angle of 270° to 360° is highly desirable.
>
> An air-to-air missile (AAM) with a 25- to 50-mile range, capable of being launched from the cruise altitude of the missile carrier and capable of attacking all air breathing targets, from sea level to 75,000 feet. The lethal radius of the warhead should be commensurate with a weapon size and weight such that 6 or more missiles can be mounted on or in the missile carrier. The missile, even though burdened with fairly high launch-angle errors, must have sufficient maneuverability to attack evasively maneuvering bombers and non-maneuvering Navaho-type missiles. This will reduce carrier-maneuverability requirements.
>
> A weapon-control system capable of exploiting the range and maneuverability of the weapons. For example, the 25- to 50-mile missile implies a required radar tracking capability of about 50 to 70 miles.
>
> An aircraft missile carrier capable of carrying the radar and weapon load just described, with a range of about 3000 nautical miles unrefueled, a cruising altitude of at least 30,000 to 40,000 feet, and a cruising speed as high as possible, but at least high subsonic.

It has been common development practice to provide the interceptor with a performance advantage over the attacking bomber. This has proved difficult in the past and is likely to become even more so in the future, since it is unlikely that a manned aircraft with

short-range weapons can be used to intercept missiles like Navaho. Therefore, the vehicles of the RAB system should remain basically the same for long periods of time, while the ability to counter various targets should be built into the radar search and tracking equipment and the AAM portions of the system.

One indication as to the manner in which radar and weapon capability can overcome an interceptor's speed disadvantage is given in Appendix 13-K, which derives vectoring limits for an interceptor with a speed disadvantage but with a 25-mile missile and a 100-mile radar. It is seen that approaches up to 60° from the bomber course may be converted into successful attacks.

Why do we not consider a conventional interceptor to be effective for these missions? There are four reasons, at least, why this cannot be recommended, and they apply to all conventional interceptors, up to and including the Air Force's planned long-range interceptor aircraft:

> They have insufficient weapon and radar range to operate outside the SAGE System.
>
> They have insufficient radar and weapon range to counter both high- and low-altitude targets.
>
> Their relatively short range would necessitate many additional bases in difficult locations.
>
> Their potential against cruise missiles of the Navaho type is extremely small; hence they do not follow the philosophy of producing a weapon system with a long useful life.

Description of Weapon System

As an example of a system to approximate the requirements just described, the elements of a long-range interceptor weapon system will be discussed. The elements will be considered in sufficient detail to give a reasonable idea of the feasibility of such a system.*

Search Radar:– Since the long-range interceptor is not a highly maneuverable vehicle, since it may be used on patrol, and since one of its major functions is the gathering of target-position data and passing it to a SAGE System Center, or to some other ground-based station, it requires a search radar with a 360° look capability, all-altitude search, and a maximum search-detection range over all kinds of terrain and water. The most promising approach to a search-radar system of these characteristic lies in the UHF band. Such a radar system is being studied and developed at the Lincoln

*Most of this work was done under separate USAF contract by a group at the Cornell Aeronautical Laboratory, Inc., working for the Air Force's Office of the Assistant for Development Planning.

Laboratory; a remarkable capability over the sea has already been demonstrated. Its capability over land and over ice is still somewhat in doubt, however, since there are little or no test data for the radar under these conditions. Because of this lack of data, conservative estimates show little capability for the UHF radar over land and over ice, even with double-delay MTI. In the suggested long-range interceptor system, a UHF search radar has been included for use against high- and low-altitude manned bomber targets over the sea, and against cruise-missile targets over the sea and over land and ice.

With these considerations in mind, a long-range interceptor radar system can be described. The characteristics are summarized in Fig. 13-10. The UHF search radar for oversea use is supplemented by an S-band search radar for overland use. Both radars would operate from the same 12 × 3 foot antenna mounted in a mushroom-type radome, top-mounted on the long-range interceptor fuselage. Ideally, after the completion of a suitable flight-test program, one radar or the other might be discarded. Note that the S-band radar is range-limited by its pulse-repetition frequency to about 50 miles. It is not power-limited. The prf is chosen at 1500 pps to enhance the clutter-cancellation capability of the MTI. These radar characteristics were established with the assistance of the Lamp Light Radar Group.

Figure 13-11 shows the range capabilities of these search radars. The ranges shown are nominally the 50 per cent blip-scan ranges, with some comment on this necessary. The ranges shown are only rough indicators of the actual detection ranges realizable

	UHF	S-band
Frequency (Mcps)	425	2880
Wavelength (cm)	70	10
Peak power (Mw)	4.0	2.0
Pulse width (μsec)	2.0	1.0
Pulse repetition frequency (pps)	400	1500
Average power (w)	3200	3000
Receiver noise figure (db)	9	9
Antenna size (ft)	12 × 3	12 × 3
Vertical beamwidth (deg)	56	8
Horizontal beamwidth (deg)	14	2
Scanning rate (deg/sec)	36	36
Moving target indicator	Double delay line	

-NS-1197

Fig. 13-10. LRI radar characteristics.

	T-39 Target				Navaho Target	
	UHF Radar		S-band Radar		UHF Radar	S-band Radar
	High	Low	High	Low	High	High
Over land	–	–	$\left(\begin{smallmatrix}120\\50\end{smallmatrix}\right)$*	50	70	50
Over sea	120	120	$\left(\begin{smallmatrix}120\\50\end{smallmatrix}\right)$*	50	70	50

*A lower prf increases the range for high targets only.

The S-band radar is prf-limited; it is not power-limited.
All ranges are in nautical miles.

-NS-1198

Fig. 13-11. LRI radar 0.5 blip-scan range capabilities.

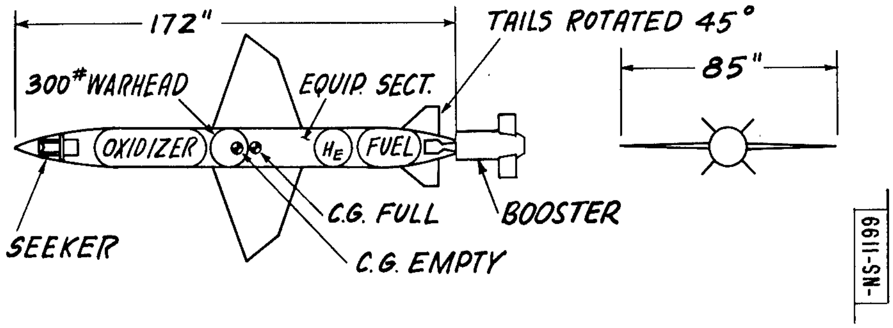
with these radars. They reflect neither target speed nor radar frame size, nor radar operator capability. On the basis of knowledge of the direction of expected attack, the angle scanned can be limited to a steerable 60° sector. The radar operator is aided by an automatic alarm. As a consequence of these techniques, it may be stated that, against manned bomber targets, the ranges shown in the figure are low, i.e., detection with high probability should occur at substantially higher ranges than those indicated. Also, against cruise-missile targets, detection with high probability should occur at about the ranges shown.

It should be noted again that the S-band radar is range-limited by its prf, and is not power-limited. A case in point is that of the high T-37 target. Over the sea, this target will probably be detected by the UHF radar first, and information from this will be used to coach the S-band radar onto the target to take advantage of the latter's more precise tracking information. But, if by doctrine or command, some of the long-range interceptors are instructed to use their S-band search radar to look for high targets only (requiring a change in prf, and a tilting of the antenna to lift the main lobe off the surface for clutter-elimination purposes), the S-band radar could make the initial detection at approximately the same range as the UHF radar over the sea, and would obtain about the same detection range over land as it would over the sea, against high targets only.

Against the Navaho-type target, the range of 50 miles shown for the S-band radar reflects its prf limitation. By use of the same technique of changing prf and antenna tilt, the 70-mile range attributable to the UHF radar against Navaho targets can also be obtained by the S-band radar.

Against mass raids, of course, detection ranges are expected to be considerably longer than shown here for single targets.

Missiles:— The philosophy of the long-range interceptor weapon system puts as much as possible of the required speed advantage over the target and maneuverability of the weapon system into the missile itself. Because it must do most of the maneuvering against the target and because it is to be used in an area in which it can have an atomic warhead, the missile can and should have long range. Since the long-range interceptor should maintain its cruise altitude, the missile must be capable of being launched at the cruise altitude of the aircraft and be guided to targets at any altitude from sea level to the altitude of missile threats. One such missile is shown in Fig. 13-12. It is a variable thrust, rocket-powered missile, boosted to Mach 2.0 and sustained at that



MISSILE DATA

Design Mach No.	2.0	Wing area (ft^2)	10
Gross wt. (lb)	1184	Body length (in.)	172
Weight empty (lb)	730	Body diagram (in.)	15
Fuel wt. (lb)	450	CG full (in.)	93.5
Rocket Thrust (lb) (variable)	700 to approx. 2400	CG empty (in.)	86.6
Duration (sec)	128	Gr. wt. missile + booster (lb)	1354

Fig. 13-12. LRI missile design.

speed. It is about 18 feet long, including its booster, with a 15-inch diameter. It has sufficient wing area for maneuver, and an all-up weight of 1400 pounds, 300 pounds of which is allowed as warhead weight and 100 for guidance electronics.

The capability zones of the missile are shown in Fig. 13-13. It has a nominal range of 30 n. mi., and a design maximum normal load factor of 4g. This load factor has been

shown to be sufficient to counter the maximum possible maneuver of a B-52, assuming that the target makes an optimum maneuver, at a missile launch range of 10 n.mi., with an initial launch angle error of 30°. These studies included the maximum errors expected in the missile control system and reflected the large lethal radius attributable to this 300-pound warhead.

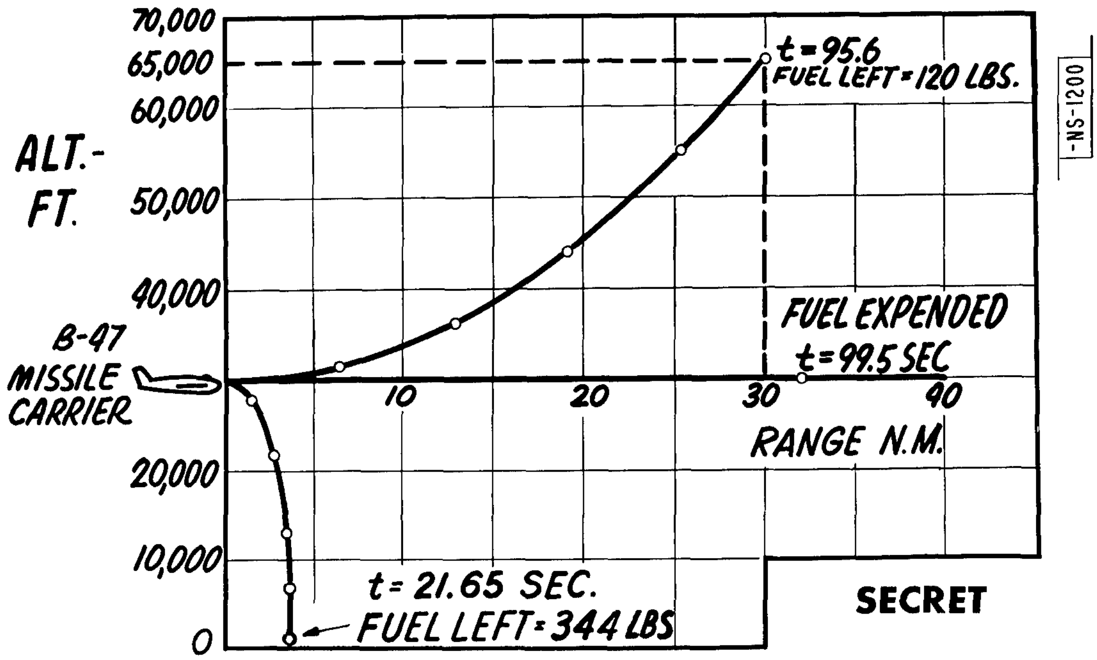


Fig. 13-13. Time history – missile flight path constant velocity = 1952 fps. Variable-thrust liquid-fuel rocket motor.

The Cornell missile studies show that suitable AAM are feasible for weights of about 1500 pounds, for all-altitude coverage from sea level to at least 75,000 feet, to a range of at least 35 n.mi.

The state of the art in missile design and development indicates that the missile would be the last in availability of the major weapon system components. It is believed that these missiles could be available by 1961 or 1962.

Weapon Control:– Many weapon-control schemes seem to be quite feasible, but insufficient results are available at present to enable a clear-cut balance of advantages and disadvantages to be made for each. The principal schemes under consideration include:

Command guidance all the way.

Infrared homing all the way against high-altitude targets.

Jammer homing all the way to counter ECM.
Command midcourse guidance followed by:
Pulse radar active homing, or
CW radar semiactive homing.

It appears that combinations of the first three schemes can be installed in the missile (these are large missiles). The choice really depends upon the precision that can be developed into command guidance. If a suitable track-while-scan device can be developed to handle tracking of target and missile simultaneously and sufficiently precisely, then command guidance all-the-way would be the choice and infrared homing would be available against very-high targets in the region where atmospheric attenuation of infrared radiation is low. A jammer homer could then be included to counter probable use of ECM by the enemy. If a compromise must be made on the precision of the command system, then radar-homing terminal guidance would be included. The semiactive CW homer would have preference here because it is available, is an all-altitude device, and eases the warhead fuzing problem, but requires the tie-up of the mother-plane radar until impact. Active radar homers release the mother-plane radar earlier, but are not available now as all-altitude devices.

Vehicles:— The first aircraft considered as a potential long-range interceptor (LRI) is a modified version of the B-47E, as shown in Fig. 13-14. It can carry eight 1400-pound AAM, four internally in the bomb bay and four externally mounted under the wings. In addition, it can mount a 12 × 3 foot antenna in a top-mounted mushroom-type radome. About two tons of electronic elements are required for the radar and control system. This complex of aircraft radar, weapons and associated equipment will gross some 220,000 pounds on takeoff.

Figure 13-15 shows the approximate mission profile of this long-range interceptor. It requires 130 n. mi. to climb to its initial cruise altitude of 23,000 feet. It cruises at 360 knots to a range of 2700 n. mi. and a final cruise altitude of 40,000 ft.

Modification of the B-47 aircraft to a suitable LRI configuration could be readily accomplished by the 1960 time period or earlier. Its ability to perform the mission plus its availability in time are the chief advantages of the B-47E configuration.

Since additional speed may be desirable in a long-range interceptor to enable it to arrive in the combat zone earlier, particularly against the Navaho cruise-missile type threat, the B-58 and Navy P6M might be later used as long-range interceptors. No detailed study has been made of their potentialities, but they seem capable of carrying

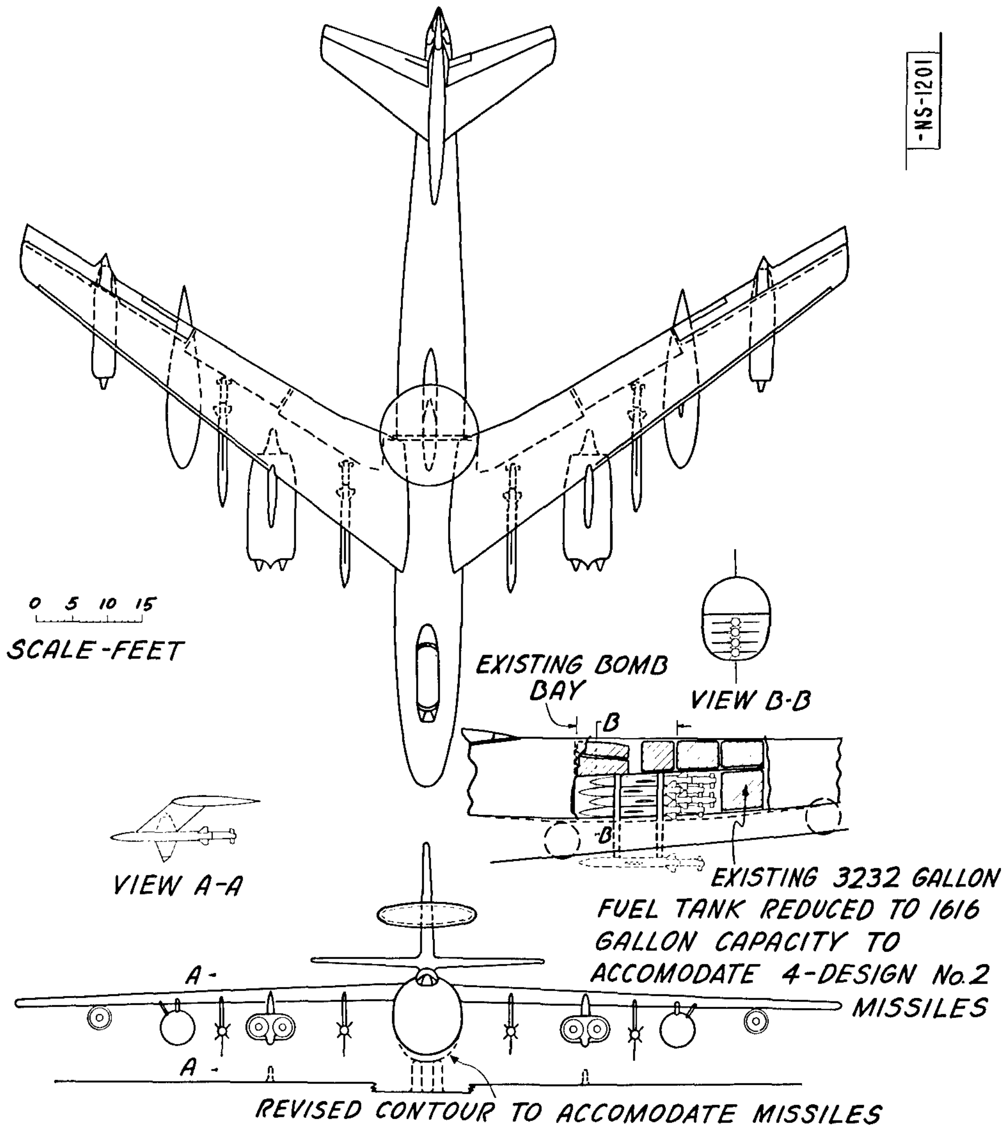


Fig. 13-14. Missile system installation, B-47E aircraft.

the required radar, and can probably carry six or more 1400-pound AAM. These aircraft certainly would lag the B-47E long-range interceptor by two years or more.

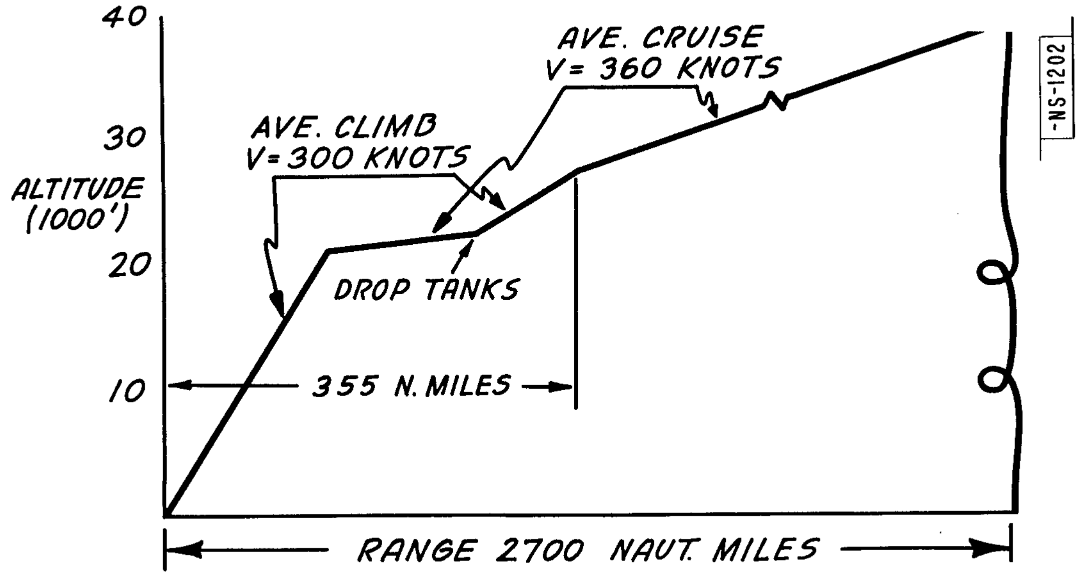


Fig. 13-15. Approximate B-47E missile carrier range profile (J-47 GE-25 engines).

Modification of existing or programmed aircraft is the speediest way to obtain operational long-range interceptors but is the least flexible. Studies based on such modifications will eventually lead to the design of an efficient new LRI aircraft. Designed as a weapon system, its speed, operating altitude, and maneuverability will be matched to its radar range, weapon range, weapon-control capability and its target. The time required for development of such a complex weapon system certainly delays its availability until 1963 or 1964. For this reason, the modification of B-58 or P6M type aircraft should also be studied.

Navigation:— To navigate the long-range interceptor efficiently, the following navigation equipments should be installed.

> Standard dead-reckoning navigation equipment.
>
> A receiver for the available ground-based navigation network.
>
> A self-contained auto-navigator of either the inertial or Doppler types.

Communications:— In general, the long-range interceptor aircraft should never be more than 900 n.mi. from friendly territory during flight. A reliable method of

transmitting information air-to-ground or ground-to-air over the above distance is required. One or more of the long-range communication methods outlined in Chapter 6 would meet these requirements.

Tactics

Potential tactical employment of the RAB forces will only be very briefly discussed. It should be recalled that the enemy action against which the remote interceptors should have their greatest capability is the large-scale, concentrated raid; consequently, tactics against such a raid will be the only ones considered.

AEW Barriers:– When a penetration in force of the AEW barriers is detected, information should be passed to the interceptor system over as great a time period as possible – at best, until interceptors contact the raid. In order to effect this depth of information, particularly against a large raid, a section of the AEW barrier would bulge inward ahead of the raid. In each of the AEW deployments considered, the barrier is at least two aircraft deep, the inner one to do the bulk of the trailing. In addition, it may be useful to launch additional AEW aircraft to aid in this information.

Intercept Tactics:– Broadcast control of interceptors, with information received from the AEW or ground-based radars or from interceptors in contact with the raid, is, of course, a possible intercept tactic.

Potential employment of this tactic is one of the factors leading to the requirement for a long-range radar in the RAB interceptor. With the postulated radar, particularly in two-plane sections and with adequate navigation aids, the interceptors should have no great difficulty in contacting a raid even when vectored from great distances on sparse information.

The long-range missiles and radar offset the speed advantage a high-performance jet bomber holds over the postulated interceptor. Computations illustrating this are given in Appendix 13-K.

Deployment of the RAB interceptors in a barrier with search-radar coverages overlapping is another possibility; but, since only those interceptors in the immediate vicinity of penetration can reach action from the barrier, care must be taken to avoid the wastage of firepower that would result from stationing the interceptors along a barrier in an unlikely region of penetration.

Two possible uses of the barrier concept are discussed on p. 49.

Attack Tactics:– The time and distances available to the RAB interceptors should be used to their greatest advantage. If the interceptors were to position themselves

along the edge of the raid and flying parallel to it, a high probability of re-attack is possible.

Since, with 25-mile missiles, interceptors with even a 4:5 speed disadvantage can keep within firing range of a moderate-size raid for a half-hour or so, deliberate firing of the weapons is possible.

Coordination of attack may be necessary if a number of interceptors are in simultaneous action against a given raid. However, since this number would be small with the deployments considered, an adequate identification system (such as coded IFF) may be sufficient for coordination.

Trailing for Information:– Information on raid activity obtained by interceptors contacting the attack may be of such importance to the follow-up RAB interceptors and to the inner defenses that surveillance of the raid after missile expenditure is indicated.

With the radars postulated, and by trailing the raid, contact may be maintained for perhaps an hour after the raid (with a 5:4 speed advantage) passes out of missile range. The interceptors considered all may execute a contact-attack-surveillance mission and still have sufficient range to reach a recovery base.

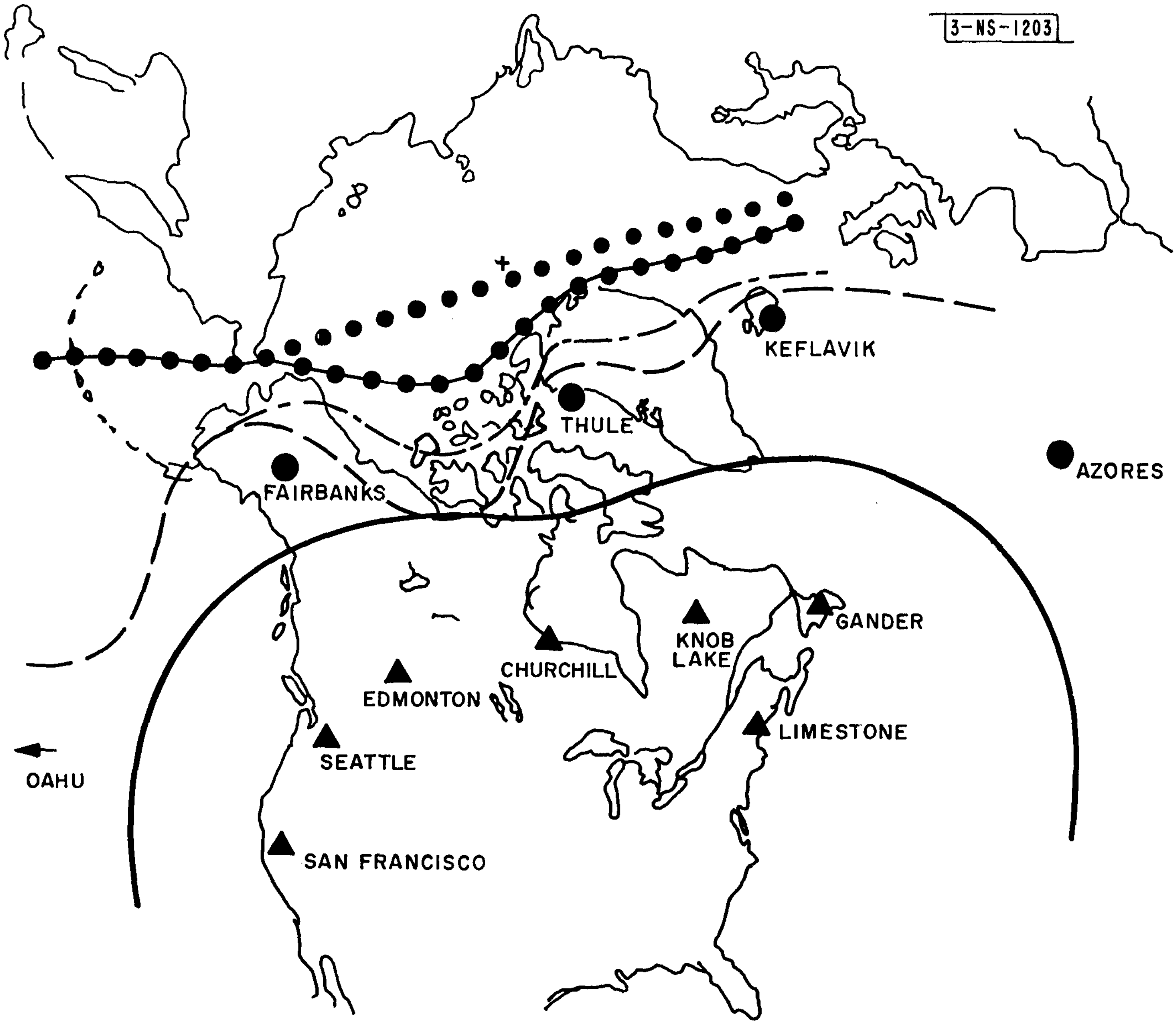
Deployment and Bases

Deployment and basing for AEW aircraft and for the RAB interceptors will be discussed for each of two missions. In the first, the objective is to extend the combat zone generally to the edge of the contiguous radar cover as spelled out previously. In the second mission, the objective is to effect as early an intercept of an enemy raid as is possible.

Combat at the Edge of Contiguous Cover:– It is recalled that the contiguous radar cover discussed for the inner defenses extends 800 to 1400 miles beyond the limits of continental United States and metropolitan Canada.

While the information on Pacific strikes as obtained in time from the Midway-Alaska warning system is sufficiently early, it is seen that intercept over Canada with information no earlier than that received from the ground-based DEW Line will not allow fulfilment of the objective unless interceptors were based at close intervals along the line.

Information in time for combat at the edge of contiguous cover could be obtained from the arctic ground-based radar line from Alaska to Thule, supplemented by AEW flights in the gap between Alaska and the Canadian archipelago and in the gap between Greenland and Norway. A description of this ground-based barrier is given in Sec. I of this chapter. The edge of this information line is shown on Fig. 13-16 (information line 2).



INFORMATION LINES

1. MIDWAY – U.K. A.E.W. ● ● ●
2. AEW, GROUND-BASED ●-●-●

BASES

1. FOR COMBAT NEAR CONTIGUOUS COVER ▲
2. FOR EARLY INTERCEPT ●

EDGE OF COMBAT ZONE.

1. NEAR CONTIGUOUS COVER ———
2. EARLY INTERCEPT WITH INFORMATION LINE 1. —— - ——
3. EARLY INTERCEPT WITH INFORMATION LINE 2. —— ——

Fig. 13-16. Information lines, bases, edge of combat zone (numerous references).

Interceptors for initiating combat at the DEW Line could be based at locations such as Edmonton, Churchill, Knob Lake and Gander. Interception in the Pacific could be effected from Seattle and San Francisco, and in the Atlantic from Gander and Limestone. In Fig. 13-16, the edge of the combat zones resulting from this deployment is shown by the heavy black line.

With the exception of Churchill and Knob Lake (needed to cover Hudson Bay), extensive facilities are already in existence at the locations listed. Churchill and Knob Lake are logistically sound locations; both are on rail lines and currently have some RCAF activity.

Interceptors operating from these locations could employ either of the basic tactics mentioned. In regions sufficiently near the remote-information zones, interception from broadcast control is quite feasible. In the ocean areas, when information is received from remote areas a barrier could be mounted at the edge of contiguous cover by ready aircraft.

Early Intercept:— For earlier intercept it is, of course, necessary to remote the interceptor bases. Interceptors for earlier intercept could be based at Oahu, Fairbanks, Thule, Keflavik and the Azores. Again, extensive installations exist at these locations. Only moderate expansion should be necessary for RAB operations.

The AEW – ground-based radar barrier described above supplies sufficient information over Canada and the North Atlantic for early intercept in most regions. The area of operation with the forward bases and information lines above is shown in Fig. 13-16 (edge of combat zone 3).

Earlier intercept from the same bases is possible if the information line is advanced. In Fig. 13-16, information line 1 represents the edge of an AEW barrier extending from Midway to the United Kindom. (While the Midway-Aleutian portion of this line is postulated for the inner defenses, the remainder must be added for RAB operation.) It is not expected that implementation of such a barrier would replace the Alaska-Greenland ground-based line, but it would be a supplement. Stations of the ground-based radar line would be used as communication centers for the AEW operation.

The entire AEW barrier described would probably not be flown except in times of tension or strategic warning.

With forward basing and the solid AEW barrier, the edge of the combat zone could be advanced as shown in Fig. 13-16.

Generally, interceptors would operate under broadcast control with information from the AEW aircraft that trail the penetrating raid. The bases mentioned are sufficiently close to the AEW barrier to allow interceptor contact before raid surveillance is lost by the AEW aircraft.

Occasionally, because of spoofing or strategic warning, it may be desirable to fly some RAB interceptors with or as part of the AEW barrier. The postulated radar and interceptor ranges are adequate for such operation.

The reduction in terms of early intercept when the information line between Alaska and the Pole is penetrated and intercept occurs only from the given bases is illustrated by the combat zone edges in Fig. 13-16. Today, no year-round northern base exists between Alaska and Thule. There is a summer airstrip and an RCAF installation at Yellowknife, on Great Slave Lake, and a permanent installation at Resolute Bay on Cornwallis Island which, when employed, could remove the inward bulge of the advance intercept region.

If the cost figures for past arctic installations such as Thule are taken as indicative of the cost of future installations, it may not appear economically feasible to build new arctic bases for the RAB forces. However, proper use of the experience in arctic construction gained at Thule, and development of new techniques, should lead to means of building arctic bases with greatly reduced expenditure. In essence, if early intercept appears desirable, examination of new base-building techniques should be explored.

Emergency landing strips exist now at the locations suggested for the arctic ground-based radars. Supplies are now often airlifted to the existing meteorological stations. The infrequent emergency use of these strips should impose little if any development beyond a fuel stockpile. Communications and shelter would, of course, be supplied by the radar and communication station.

The deployment of the RAB system has been examined in terms of three levels of expenditure, in the context of the over-all defense system.

Low-Level Expenditure:— In addition to the AEW aircraft operating out of Midway, one wing (45 planes) is based as follows: Fairbanks, 25; Keflavik, 20. These aircraft supplement the Canadian Archipelago ground-based radar line and give the inner information line as shown in Fig. 13-16.

Six squadrons of long-range interceptors (totaling 90 interceptors) are deployed as shown in Table 13-I.

This deployment allows intercept at the inner combat line as shown in Fig. 13-16 except in the lower Pacific region.

Medium-Level Expenditure:– The early-information system is the same as that for low-level expenditure.

Interceptors are based to initiate early intercept. The bases and deployment are given in Table 13-I. Twenty-four squadrons are available.

TABLE 13 – I

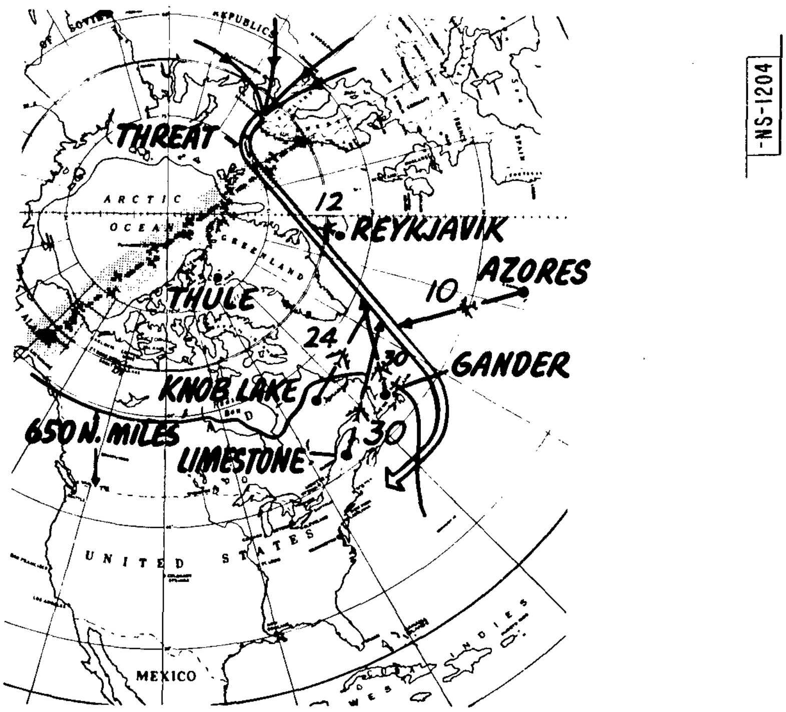
DEPLOYMENT OF RAB INTERCEPTORS
(In Squadrons of 15 Aircraft)

Base	Cost Level		
	Low Cost	Medium Cost	High Cost
Oahu		1	1
San Francisco		1	1
Seattle		1	2
Fairbanks		1	2
Edmonton	1	3	4
Churchill	2	3	5
Knob Lake	2	3	5
Gander	1	3	5
Thule		2	3
Limestone		3	5
Keflavik		2	2
Azores		1	1
TOTAL	6	24	36

Deployment is chosen to give roughly a 3:1 weighting in favor of the heartland over the Pacific coast; this is consistent with the deployment of the inner defenses.

Intercept can occur at the middle combat zone edge as shown in Fig. 13-16.

High-Level Expenditure:– Three wings (135 AEW aircraft) are divided between Fairbanks and Prestwick to implement the Alaska-United Kingdom barrier when desirable. Interceptors are based as in the medium-level expenditure, but in greater numbers. The figures are given in Table 13-I. Thirty-six squadrons are available. The information line and the edge of the combat zone are the outer ones of Fig. 13-16.



AEW radar coverage zone

LRI (speed 350 knots)

Raid (250 × 50 n.mi; speed: 550 knots)

LRI BASES	AVAILABLE LRI	NO. OF ATTACKING LRI
Thule	20	0
Reykjavik	20	12
Gander	30	30
Knob Lake	30	24
Limestone	30	30
Azores	10	10
TOTAL	140	106

Fig. 13-17. Combat potential of LRI system.

Effectiveness of the LRI Weapon System

Operational Capability:— Table 13-II and Fig. 13-17 show the operational capability or maximum combat potential of the LRI system against a "typical" threat that originates in northwestern Russia. The raid flies an overwater route between Greenland and Iceland, keeps out of the contiguous-cover combat zone for as long a period as possible, and finally swings in over the Boston-New York City area to the heartland.

TABLE 13 – II			
RAB INTERCEPTORS COMMITTED TO THE "TYPICAL" RAID			
Base	Numbers Committed		
	Low Cost	Medium Cost	High Cost
Keflavik	0	12	12
Azores	0	10	10
Knob Lake	16	24	40
Gander	10	30	50
Limestone	0	30	50
Others	0	0	0
TOTAL	26	106	162

It is assumed that the dead time of the system is such that the first LRI's are airborne when the raid crosses the center of the AEW coverage zone — a period of some 20 minutes or so after first detection for a 550-knot raid. All aircraft that can make suitable interception along the projected track of the raid are committed as soon as possible according to the availability schedule which, for a 15-plane squadron, is assumed to be:

2 in 5 minutes,
2 in 25 minutes,
2 in 50 minutes,
2 in 90 minutes,
2 in 120 minutes.

The commitment doctrine of sending every aircraft available as soon as possible is based on the system characteristics. These aircraft have an operational range of 2700 n.mi. plus standard reserves. If the aircraft in the raid change course, split, or are feinting for a punch by a following raid, this will be known in time to redirect the LRI's accordingly after they are airborne. (A change in direction means a longer path, with consequently more time to fight, or a shorter path to the heartland, which

can only pass more nearly over the LRI base complex and hence, result in a higher number of LRI's entering the combat.) No combat is allowed to take place, in this example, within 650 miles of the heartland, the outer boundary of the inner defense system combat zone.

A raid that splits will allow more LRI's to be brought into combat, with a consequently higher kill potential. A raid that changes course can do little better for itself than the raid described. A raid that is feinting, for another larger punch to appear elsewhere, can be roughly estimated in size (for commitment purposes) as it passes through the AEW line. If it is large, full commitment can be made immediately. If another raid follows, the commitment can be changed while the LRI's are airborne, because of their very large range. In fact, because these LRI's can remain airborne for more than 7 hours, a feint will be unprofitable because it will alert the entire system and considerably reduce the system dead time on the main raid.

As an alternative example, if the same raid chooses a path overland through the Hudson Bay hole into the heartland, the numbers of aircraft that may be brought into combat are, respectively, 50, 140, and 182 for the three cost levels.

System Costs:— Estimated cost of the RAB system, in terms of the ADR 54-60 budget level, and the associated warhead-delivered potential are given in Table 13-III.

Details of the costing method and estimated weapon effectiveness are given in Appendices 13-I and 13-J.

TABLE 13 – III

COST AND EFFECTIVENESS OF THE REMOTE AIR BATTLE SYSTEM

Total System Cost in per cent of ADR/54-60	AEW Aircraft Obtained	Interceptors Obtained	Warhead-Delivery Potential against a Mass Raid	
			Over Hudson Bay	Over North Atlantic
2.5	45	90	400	208
9.0	45	360	1120	848
13.8	135	540	1456	1296

Conclusions and Recommendations: Remote Air Battle

In order to summarize this discussion of the remote air battle and the long-range interceptor weapon system, the Project Lamp Light conclusions and recommendations are presented below.

General Conclusions:– A remote air battle capability will improve continental air defense by:

> Increasing the flexibility of air defense operations,
>
> Improving the information and kill potential of the inner defenses,
>
> Extending the area over which air defense operations can be conducted.

The long-range interceptor weapons system is technically feasible and can be employed in the missions associated with the remote air battle. If this system is employed, the continental air defense will be improved as follows:

> The distance from the heartland areas at which interceptions can be made may be extended from about 700 to over 2000 nautical miles.
>
> The ability to use atomic weapons of several types under conditions of improved tactical freedom will be available to CONAD.
>
> A further deterrent to the Soviet striking force will have been provided.

Specific Conclusions:– More specifically, Project Lamp Light concludes that:

> The long-range interceptor described in this chapter can be used in three different types of missions: flying armed patrols, passing information back to the inner defenses of the United States, and flying interceptor missions against all airbreathing targets.
>
> A long-range interceptor weapon system and its associated radar and air-to-air missiles can be developed by 1961-62.
>
> The radar and missile elements of the long-range interceptor weapon system can be developed to find and intercept targets from sea level to 75,000 feet altitude.
>
> This weapon system can be employed for remote air battle operations and will provide, in part, a more effective air defense against manned bombers and airbreathing surface-to-surface missiles in a zone some 2000 nautical miles wide around the continental United States.

Recommendations

1. We recommend the development of a long-range interceptor radar system comprising both UHF and S-band radars. Detailed experiments of both radars against low-flying targets over land and sea are recommended to see if this system can be improved.

2. We recommend the development of long range air-to-air missiles with jump-up and jump-down capabilities.

3. For earliest operational introduction of this weapon system, we recommend modification of the B-47E aircraft to carry a large antenna radar, and missiles.

4. We recommend that the employment of modified B-58 or Navy P6M-1 aircraft, or the development of a new high-speed, long-range interceptor aircraft be reviewed by the USAF. If higher cruise speed shows a sufficient pay-off in the air defense roles, we recommend that a new long-range interceptor be programed for later introduction into the air defense system.

CHAPTER 13 RECOMMENDATIONS

The Remote Information Zone

Information Gathering: Barriers

1955 – 1958

1. *We recommend extension of the DEW line by using programed AEW aircraft and pickets on continuous patrol from Hawaii to Kodiak Island, and from Argentia the Azores, with periodic patrols to close the gap from Cape Dyer to Cape Farewell.*

2. *To provide earlier information on high-altitude penetrations through the area north of Hudson Bay, we recommend that alarm radars of the Sentinel type be installed at the Joint Canadian-U. S. Arctic Weather Stations.*

1957 – 1960

To prevent end runs, provide more warning-time, and improve low-altitude detection, we recommend:

1. *Extension of the land barrier along the Aleutian chain to Adak.*

2. *Extension of the DEW coverage by gap fillers in the radar chain from Kodiak to Cape Lisburne.*

3. *A radar station at Holsteinborg (Greenland), and a picket ship in the Davis Strait.*

4. *Investigation of the possibility of closing the gap across the Davis Strait with long Fluttar links.*

5. *A radar station in King Christian IX Land (East Greenland) and four manned radar stations on the Greenland ice cap.*

6. *Four radar stations in Iceland.*

7. *At least one radar station in the Faeroes.*

8. *One picket ship between Iceland and the Faeroes.*

9. *Redeployment of AEW aircraft in the Atlantic as required for contiguous cover. In the Pacific, investigation of the feasibility of basing AEW aircraft on Midway to substitute a Midway-Adak line for the previous Hawaii-Kodiak line.*

1960–1965

1. *To provide information that will permit interception in the remote zone, we recommend AEW aircraft patrols from the Aleutians north to the Pole, thence to Northern Scotland.*

2. *We recommend the establishment of radar stations in Northern Greenland for the defense of Thule and for the completion of an additional complete barrier from Cape Parry to Iceland.*

Information Gathering: General Surveillance

For the Ocean Areas, we recommend that ocean shipping be organized into a general surveillance system in the North Atlantic and Pacific Oceans as rapidly as possible. Subsidiary recommendations towards this end are:

1. *That tests of the communications processes be initiated at once, and improvements undertaken where necessary.*

2. *That such radars as are available, both surface- and air-search types, be employed as soon as the system is organized.*

3. *That as an interim measure, radars of the AN/TPS-1D and SRa types be installed in selected classes of ships.*

4. *That the development and installation of more suitable radars be carried out within 18 to 24 months.*

5. *That one U.S.-controlled Ocean Station Vessel be reactivated in the North Atlantic and that two such be activated in the Pacific.*

6. *That radars and, in certain cases, communication centers be installed on such islands as Sable, Bermuda, Azores, Midway, Wake, etc., as parts of the ocean areas general surveillance system.*

7. *That the fishing fleets operating well off the North-east coast of North America be organized into a type of Ground Observer Corps, using where practical radars of the Chipmunk type.*

For the Land Areas, we recommend:

1. *That the Canadian authorities be invited to consider the installation of a general surveillance system in Northern Canada, in a manner which will complement the DEW and Mid-Canada Lines and plans for high altitude radar cover.*

2. *That radars of low information rate and low manning requirements such as the Chipmunk, Super Chipmunk, Sentinel, and a smaller-antenna type of Sentinel, be further developed and exploited.*

3. *That further study be given to methods proposed for filling the Hudson Bay, Davis Strait, and other water or pack-ice gaps.*

4. *That the use of Chipmunk type radars in the Alaskan GOC be commenced.*

5. *That the principle of using all military and governmental outposts as radar data sources be further considered in possible extensions such as Greenland and the Bering Sea.*

6. *That the possible exploitation of military and commercial transport aircraft as radar data sources for general surveillance be further examined.*

7. *That the number of codes available on the ANDB beacon be increased to 62 and its use by all transoceanic traffic be encouraged.*

The Remote Air Battle

1. *We recommend the development of a long-range interceptor radar system comprising both UHF and S-band radars. Detailed experiments of both radars against low-flying targets over land and sea are recommended to see if this system can be improved.*

2. *We recommend the development of long range air-to-air missiles with jump-up and jump-down capabilities.*

3. *For earliest operational introduction of this weapon system, we recommend modification of the B-47E aircraft to carry a large antenna radar, and missiles.*

4. *We recommend that the employment of modified B-58 or Navy P6M-1 aircraft, or the development of a new high-speed, long-range interceptor aircraft be reviewed by the USAF. If higher cruise speed shows a sufficient pay-off in the air defense roles, we recommend that a new long-range interceptor be programed for later introduction into the air defense system.*

APPENDICES TO CHAPTER 13

APPENDIX 13-A

CHARACTERISTICS OF PROPOSED ALEUTIAN RADAR SITES

MT. MOFFET

Alaska Recon. Topo. Series, Adak, 1/250,000
N Adak Island, 51°.58' N, 176° 45' W
Atop Mt. Moffet, about 5-1/2 miles NW of Davis Air Force Base and 3-1/2 miles WSW of NW corner of Andrews Lagoon.

CONTINUITY OF INFORMATION LINE

Range:- 88 miles.

Relation to Adjoining Stations:- South about 1650 miles to Midway Island (AEW link); east-northeast 115 miles to Korovin (98-mile range).

SUMMARY:- The site is an exposed position of the highest elevation in more than 15 miles; nearby are landing and operational facilities of an Air Force base. BUT it will require construction of about 3-1/2 miles of winding road; the climate is cool, moist and windy.

LANDING CONDITIONS

Depth, Protection, Tides:- Kuluk Bay, on the east central coast, is a good harbor with no sunken rocks but is somewhat exposed to the northeast; tidal range is 2 to 6 feet.

Facilities:- Docks and landing facilities are available on the northern and western sides of Sweeper Cove, off the southwest corner of Kuluk Bay. Roads extend from here to Davis Air Force Base (about 1-1/2 miles to the north) where aircraft landing facilities are available. Sudden and violent winds may be experienced in an Aleutian port, or fog may hinder navigation; but the port is likely to be open all year.

ACCESSIBILITY:- Part of the road system extends rather directly about 7-1/2 miles from the docks to the northwest corner of Andrews Lagoon by way of the Air Force base. From the Lagoon southwest, a winding road about 3-1/2 miles long will have to be built on the north face of the mountain. Possibly, construction of a road to the site would be less difficult on the more protected southeast side of the mountain where a 4- to 5-mile winding road could lead directly from roads at the northwest corner of the Air Force base.

ELEVATION AND SURFACE CONFIGURATION:- The top of Mt. Moffet is 3900 feet above sea level.

WATER SUPPLY:- Water might be obtainable at the Air Force base.

NEARBY FACILITIES

Communications:- An existing ACS (Alaska Communication System, Signal Corps, Dept. of the Army) circuit exists from Adak south to Seattle, east to Unalaska and Kodiak, and northeast to Anchorage.

Transportation:- The Air Force and Military Sea Transport (MST) very likely operate on schedule to supply military installations in the Aleutians and would be available for resupply of the radar station. Reeve Aleutian Airways has scheduled flying to Adak.

Villages:- No villages are nearby.

ADDITIONAL REMARKS:- Mt. Moffet is an inactive volcano, and volcanic activity is not expected; however, earthquakes should be expected. Mean monthly temperatures will range from about 33°F in December, January and February, to about 52°F in August; total precipitation will be about 70 inches a year, distributed evenly and including about 50 inches of snow; possibly 10 per cent of the days will be clear, with a higher probability in the winter. The wind will be largely northwesterly, with average monthly velocities of 10 to 15 mph in summer and somewhat less in winter.

KOROVIN

Alaska Recon. Topo. Series, Atka, 1/250,000
NE Atka Island, 52° 23' N, 174° 10' W
N face near top of Korovin Volcano, about 15
miles N of Atka village at W end of
Nazan Bay

CONTINUITY OF INFORMATION LINE

Range:- 98 miles.

Relation to Adjoining Stations:- West-southwest 115 miles to Moffet (88-mile range); east 147 miles to Yunaska Island (78-mile range).

SUMMARY:- The site is an exposed position on the north face of the highest elevation within about 100 miles; knowledge of navigation and landing facilities for small vessels in Nazan Bay is available; a village and an airport for DC-3 type planes are present on the island. BUT the site will require construction of about 12 miles of road. It is possible that the volcano and the nearby active Sarichel Volcano may show signs of activity at any time. It will be difficult to place the radar on top of the mountain and may be necessary to place it on the north slopes, thus blocking coverage to the south.

LANDING CONDITIONS

Depth, Protection, Tides:- Nazan Bay, on the eastern side of the island, has an outer harbor that is exposed to the east and has a bottom with depths of 15 to 20 fathoms and sand or volcanic ash. The inner harbor, just east of the village, is somewhat exposed to the northeast, and depths are 6 to 12 fathoms with anchorage in a sticky bottom that provides not particularly good holding. Entrance to and movement through the inner harbor must be done with care. Tides in the bay are chiefly diurnal and range about 3-1/2 feet.

Facilities:- Small vessels are beached at the village where the Bolshoi Island offers protection from northeasterly winds; no docks are known to be present. Sudden and violent winds may be experienced, or fog may hinder navigation, but the port is likely to be open all year.

ACCESSIBILITY:- A short road system extends from the village along the head of Nazan Bay and west across the lowland toward Korovin Bay. The road ends at the midwest shore of a small lake in the lowland, about one mile from Korovin Bay. From near the east end of the lake a road about 12 miles long would have to be built to reach the proposed site; the last mile or two would be difficult.

ELEVATION AND SURFACE CONFIGURATION:- The top of Korovin Volcano is about 4852 feet above sea level; the station would be either atop or about 100 feet below it on the north side.

WATER SUPPLY:- Water might be obtained from the lake between the heads of Nazan and Korovin Bays. Fresh water for the village is procured from a nearby stream; another probable supply is at a waterfall about 2 miles south of the village.

NEARBY FACILITIES

Communications:- The Territory of Alaska had radio station KLF there at one time; possibly it is still in operation.

Transportation:- The Air Force and MST very likely operate in this area to supply military installations westward. There is a seaplane anchorage between Bolshoi Island and the village. Reeve Aleutian Airways has scheduled flying to the airfield near the village; probably DC-3 aircraft are used.

Villages:- The village of Atka had a 1951 population of 98, all Aleut.

ADDITIONAL REMARKS:- Korovin Volcano may be dormant rather than inactive; earthquakes should be expected. From 10 to 17 years of weather observations there, the following may be expected: mean monthly temperature ranges of 33°F in December and January to 52°F in August; total precipitation of about 70 inches a year, distributed evenly and including about 50 inches of snow; possibly 10 per cent of the days clear, with a higher probability in winter; and winds from the northwest at averages of 10 to 15 mph in summer and somewhat less in winter.

YUNASKA

Alaska Recon. Topo. Series, Amukta, 1/250,000
Central SW Yunaska Island, 52° 36' N, 170° 17' W
Atop unnamed volcanic peak about 2 miles inland
from central W coast of island

CONTINUITY OF INFORMATION LINE

Range:– 78 miles.

Relation to Adjoining Stations:– West 147 miles to Korovin (98-mile range); east-northeast 87 miles to Nikolski (33-mile range).

SUMMARY:– The site is an exposed position on the highest elevation within 30 miles, with a probable source of water at a nearby lake. BUT a 9-1/2-mile road will have to be built; the unnamed volcanic peak is the top of an active volcano; there is only a poorly protected anchorage for vessels, and no landing facilities for vessels or aircraft.

LANDING CONDITIONS

Depth, Protection, Tides:– Anchorage for small vessels is probably available in a bay, South Ancho, in the mid-south shore of the island, which is unprotected to the south and should be approached with care because of rocks on either side of the entrance. It is possible that sudden violent winds may be experienced in this anchorage. The tides are probably about 3 feet and the anchorage is probably open all year.

Facilities:– Small craft might be beached at the head of South Ancho, but there are no docks.

ACCESSIBILITY:– There are no roads or landing facilities for aircraft on the island.

ELEVATION AND SURFACE CONFIGURATION:– The top of the unnamed volcanic peak is 3119 feet above sea level; the station should be on the top.

WATER SUPPLY:– Water supply is possibly available at the small lake between the anchorage and the radar site, and there may be several small streams on the south side of the unnamed peak that is the proposed site.

NEARBY FACILITIES

Communications:– There are no communication facilities at the island.

Transportation:– The Air Force and MST very likely operate in this area, but there are no landing facilities for aircraft or vessels.

Villages:– No village is nearby.

ADDITIONAL REMARKS:– Climatically, Yunaska is similar to Atka with perhaps a little less total precipitation and somewhat more snow than at Atka, particularly at the exposed proposed site.

NIKOLSKI

Alaska Recon. Topo. Series, .Samalga Island, 1/250,000
SW Umnak Island, 52° 54' N, 168° 45' W
On Cape Udak near triangulation point "Drift," about
4 miles SE of Nikolski village

CONTINUITY OF INFORMATION LINE

Range:– 33 miles.

Relation to Adjoining Stations:– West-southwest 87 miles to Yunaska (78-mile range); northeast 56 miles to Fort Glenn (62-mile range).

SUMMARY:– Position affords line-of-sight connection west to Yunaska through Islands of Four Mountains and longest line of sight possible to northeast that is free of great surface irregularities of interior Umnak Island; a village is near the proposed site, and water is likely available from lakes within 5 miles of the site. BUT a road about 5 miles long will have to be built from the village of Nikolski to the site.

LANDING CONDITIONS

Depth, Protection, Tides:– Anchorage in 12 fathoms is available in the outer harbor of Nikolski Bay; however, this is open to westerly and northwesterly winds. Small vessels can approach the shore more closely and can enter the inner harbor through a narrow passage of 4 fathoms, but great care must be exercised because of rocks along the shore of the bay. There is a good shingle beach in front of the village and seldom any surf.

Facilities:– No docks are known to be present. The harbor is probably open all year and has occasional fog.

ACCESSIBILITY:– Roads run northeast and southwest from Nikolski village, generally close to the western shore. A 5-mile road will have to be built southeast from the village to the outer part of Cape Udak; construction should be relatively easy.

ELEVATION AND SURFACE CONFIGURATION:– The triangulation point is 545 feet above sea level. A 600-foot elevation in the middle of the Cape should be utilized; that part of the island to the west of the Cape includes a few points nearly 400 feet high, and north of the Cape elevations are 500 to 600 feet. In the central part of the island is the active volcano, Mt. Vsevidof, and the nearby extinct volcano, Mt. Recheshnoi; therefore, earthquakes should be expected at the proposed radar site.

WATER SUPPLY:– Water might be obtainable from one of the lakes near the base of Cape Udak; also, a large lake adjoins the eastern side of Nikolski village.

NEARBY FACILITIES

Communications:- Radio communication is available from Nikolski village to the ACS station at Unalaska, and thence to Anchorage or Kodiak.

Transportation:- The Air Force and MST very likely operate on schedule in this area, but there are no landing facilities for aircraft, and only small vessels can enter the inner harbor of Nikolski Bay.

Villages:- Nikolski village in 1950 had a population of 64 (5 white, 56 Aleut, and 3 other).

ADDITIONAL REMARKS:- The Nikolski climate might include the following: temperature ranges of 31°F in January to 53°F in August; an annual precipitation of 58 inches, with a tendency toward summer being drier and with a total snowfall of about 70 inches; an average of about 10 per cent of the days of each month clear; winds mostly northwesterly at average velocities of 10 to 15 mph in summer and somewhat less in winter.

FORT GLENN

Alaska Recon. Topo. Series, Unalaska, 1/250,000
NE Umnak Island, 53° 27' N, 167° 43' W
Atop isolated 1900-foot peak about 6 miles due N of Fort Glenn Airfield and 5-1/2 miles SW of NE corner of Umnak Island, Cape Idak

CONTINUITY OF INFORMATION LINE

Range:– 62 miles.

Relation to Adjoining Stations:– Southwest 56 miles to Nikolski (33-mile range); northeast 106 miles to Gilbert (73-mile range); not line of sight between Gilbert and Fort Glenn, overlap of radars at point north of north-central Unalaska Island.

SUMMARY:– Use of this site reduces (by at least one) the number of stations that would be necessary to obtain coverage by sites on the mountainous north coast. The site is next to the location of the Fort Glenn Air Force Base (still manned?), in an exposed position on the northeast tip of the island; only about one mile of road construction would be necessary. BUT a radar here and at Nikolski would be blocked in a triangular area extending 20 miles (maximum) northwest from the northwest coast of northeast Umnak Island. To use this triangle, however, aircraft would have to approach from the northwest at elevations of less than about 5000 to 7000 feet, and then cross the island at the base of the triangle at minimum elevations of 3000 to 4000 feet (because of the surface), at which points the aircraft could be identified on the radars at Nikolski and/or Fort Glenn. Between these two stations coverage may not be on a line of sight; if not, it is very close to line of sight along the southeast shore of the island. It is questionable if there are suitable landing facilities for vessels in the vicinity of the proposed site.

LANDING CONDITIONS

Depth, Protection, Tides:– The shore along the south side of Fort Glenn is fringed by rocks and comparatively shallow water (less than 10 fathoms to 1-1/2 miles offshore), and is backed by cliffs up to 200 feet high. There are heavy rip tides that make small-boat navigation dangerous. Anchorage is available in Otter Bay (Bight) at the northeast corner of Fort Glenn, but it is exposed to the east. Sudden strong winds as well as fog might be experienced there.

Facilities:– There possibly are landing facilities for vessels supplying Fort Glenn; the anchorage would be open all year.

ACCESSIBILITY:– A road system is in Fort Glenn from which a road extends north to the airport on the north coast; a new road about one mile long, east from the middle of the existing road, would reach the proposed site.

ELEVATION AND SURFACE CONFIGURATION:- The elevation of the peak is 1918 feet, which is 500 to 1000 feet higher than elevations within about 5 miles in any direction. A volcanic peak and crater to the west and southwest, however, are about 3500 and 4100 feet high.

WATER SUPPLY:- Water may be available from existing streams within about 5 miles of the site, and from the Fort Glenn site.

NEARBY FACILITIES

Communications:- No existing communication facilities are known; but if Fort Glenn is in operation, a radio link to Anchorage should exist.

Transportation:- The Air Force and MST probably operate in the area; aircraft could land at one of 3 fields in or near Fort Glenn, but docking of vessels is questionable.

Villages:- No village is nearby.

ADDITIONAL REMARKS:- The climate might include temperature ranges of about 30°F in January to about 53°F in August; an annual precipitation of about 58 inches with a tendency toward summer being drier and with a total snowfall of about 70 inches; an average of about 10 per cent of the days of each month clear; and winds mostly northerly to northwesterly at average velocities of 10 to 15 mph in summer and somewhat less in winter. The possibility of earthquakes and of volcanic activity at nearby Okmok Volcano (to west) should be anticipated.

GILBERT

Alaska Recon. Topo. Series, Unimak, 1/250,000
NW Akun Island, 54° 15' N, 165° 39' W
Atop Mt. Gilbert in center of NW peninsular part of island

CONTINUITY OF INFORMATION LINE

Range:– 73 miles.

Relation to Adjoining Stations:– Southwest 106 miles to Fort Glenn (62-mile range); not line of sight between Gilbert and Fort Glenn, overlap of radars at point north of north-central Unalaska Island; northeast 127 miles to Fort Randall (31-mile range); Gilbert and Fort Randall not quite line of sight because of Shishaldin Volcano on Unimak Island, but radar coverage quite sufficient.

SUMMARY:– The site is in an exposed position affording nearby line-of-sight coverage on the north side of this portion of the Aleutians both to the southwest and northeast. The use of this extinct volcano for a site allows for passing over two active volcanoes to the west (between Gilbert and Fort Glenn) and four active volcanoes to the east (between Gilbert and Fort Randall). BUT it will be necessary to construct landing facilities and a 6-1/2-mile winding road to the site; the supply of water may be a problem.

LANDING CONDITIONS

Depth, Protection, Tides:– Lost Harbor, on the west side of Akun Island, affords fairly good shelter, although considerable swells accompany northwest winds (probably the prevailing winds). Depths of 6 fathoms are 1/8 mile offshore.

Facilities:– No facilities for vessels are known to be present, although it is possible that some remains of a dock are present on the north shore near the remains of a former sulphur mine. The harbor is open all year and subject to fogs.

ACCESSIBILITY:– It will be necessary to construct a 6-1/2-mile winding road from the head of Lost Harbor to the radar site, which may involve considerable winding, particularly for the last 800 feet vertically.

ELEVATION AND SURFACE CONFIGURATION:– The elevation of the peak is 2685 feet – at least 800 feet higher than elevations in all directions but west, where elevations of more than 3000 to 4000 feet are reached at distances of about 12 miles from Gilbert.

WATER SUPPLY:– Water may be available from streams or small lakes near the head of Lost Harbor, but it should be anticipated as problematic on the basis of local sources.

NEARBY FACILITIES

Communications:- No known communication facilities are present.

Transportation:- The Air Force and MST very likely operate on schedule in the area, but there are no known facilities for the landing of planes or vessels.

Villages:- The nearest village is Akutan, about 11 miles southwest of the head of Lost Harbor and on Akutan Island; the 1950 population was 86 (21 white and 65 Aleut).

ADDITIONAL REMARKS:- The climate might include temperature ranges from about 30°F in January to about 53°F in August; an annual precipitation of about 60 inches; an average of 15 to 20 per cent of the days of each month clear; and winds probably northwest at average velocities of 8 to 10 mph in summer and somewhat less in winter. The possibility of earthquakes should be anticipated.

FORT RANDALL

Alaska Recon. Topo. Series, Fort Randall, 1/250,000
SW Alaska Peninsula, 55° 07' N, 162° 48' W
On 4200 foot elevation midway between Cold Bay and Morzhovoi Bay, about 3 miles N of Frosty Peak and 5-1/2 miles SW of Fort Randall.

CONTINUITY OF INFORMATION LINE

Range:– 91 miles.

Relation to Adjoining Stations:– Southwest 127 miles to Gilbert (73-mile range); Fort Randall and Gilbert not quite line of sight because of Shishaldin Volcano or Unimak Island, but radar coverage quite sufficient; northeast 136 miles to Stepovak Bay (111-mile range); not quite line of sight because of Pavlof Volcano between, but radar coverage quite sufficient.

SUMMARY:– The proposed site is near the existing Thornbrough Air Force Base and adjoining Fort Randall where there are landing facilities for planes and vessels, and supply and living facilities for personnel. The position of the site is exposed in all directions except due south. BUT a road about 6 miles long, from the existing road system, will have to be constructed; the last 2 to 3 miles will very likely be winding.

LANDING CONDITIONS

Depth, Protection, Tides:– Much experience has been had in operating vessels and aircraft in the Cold Bay area. The bay is about 10 miles north to south by about 4 miles east to west with an entrance. Depths may be sufficient for transport vessels to proceed directly to the dock, but local information should be procured to do so. The bay is open to the south and offers poor protection from frequent heavy seas from that direction; fogs and sudden strong winds in the harbor area should be anticipated.

Facilities:– Docking facilities are available adjacent to the Air Force base about 8 miles north of the entrance to the bay on the west side. These facilities and the bay should be usable all year, except during local weather disturbances.

ACCESSIBILITY:– It will be necessary to construct a road about 6 miles long from the existing road southwest of Fort Randall on southwest to the site. A road system is present from the west side of the entrance to the bay, through the fort and landing-field area to the north shore of the Alaska Peninsula.

ELEVATION AND SURFACE CONFIGURATION:– The site is on a 4200-foot peak about 3 miles north of Frosty Peak, 6600 feet high. Other than the latter peak, the site is about 2000 feet higher than the elevations within 15 miles.

WATER SUPPLY:– Water may be available at the military bases; local lakes and streams are numerous.

NEARBY FACILITIES

Communications:– One ACS circuit connects Fort Randall with Anchorage, and another with Kodiak.

Transportation:– The Air Force and MST operations to the Cold Bay bases are probably scheduled, so resupply of the radar base should be relatively easy.

Villages:– The nearest settlement is King Cove, about 20 miles southeast of Fort Randall, which is a town of 162 people (1950 census) – 17 white, 143 Aleut, and 2 Eskimo.

ADDITIONAL REMARKS:– The climate might include temperature ranges from 33°F in December to 51°F in August; an annual precipitation of about 50 to 60 inches, including about 30 inches of snowfall and a heavier concentration from July through November; 10 to 30 per cent of the days of the month clear, with July and August being lowest; and winds prevailingly from the northwest or southeast with average velocities of 5 to 10 mph. The possibility of earthquakes attending volcanic activity within 50 miles of Cold Bay should be anticipated.

STEPOVAK

Alaska Recon. Topo. Series, Chignik and Stepovak
Bay, 1/250,000
Central Alaska Peninsula, 56° 02' N, 159° 48' W
Atop prominent peak about 12 miles due N of W end of head of Stepovak Bay and about 18 miles SW of SW tip of Veniaminof Crater

CONTINUITY OF INFORMATION LINE

Range:– 111 miles if 6200-foot elevations attainable; 105 miles if peak elevation is only about 5500 feet.

Relation to Adjoining Stations:– Southwest 136 miles to Fort Randall (91-mile range); not quite line of sight because of Pavlof Volcano between, but radar coverage quite sufficient; northwest 200 miles, across Bristol Bay, to Cape Newenham (72-mile range, with tower); 16- to 20-mile gap will be between the range of Stepovak and Cape Newenham.

SUMMARY:– The use of this proposed site makes possible the near-complete "bridging" of Bristol Bay as far west as possible; this is significant in preventing this part of the information line from extending 175 miles to the east and, therefore, offering insufficient warning time for the Kodiak base. By the use of this site, the number of radar stations needed for a continuous line around Bristol Bay is reduced by at least 5. BUT, this site is the most difficult to use of the southwest Alaskan and Aleutian Islands. There is a question as to whether the elevations here are about 5500 or exactly 6211 feet; the difference results in widening the radar gap over Bristol Bay by about 4 miles. However, there is the possibility of continuous snow at these elevations, which will complicate the problems of installation and maintenance. In addition, a 16-mile road will have to be built, as well as landing facilities for vessels.

LANDING CONDITIONS

Depth, Protection, Tides:– Depths in Stepovak Bay are poorly known; shoals should be anticipated at the head of the bay and isolated rocks are known to be close to the northwest shore. The bay is open to the south and offers little protection from frequent heavy seas from that direction. Fogs in the area are common, particularly in summer; and sudden strong winds in the bay should be expected, particularly during strong northwest winds in the area.

Facilities:– Docking facilities are absent, but the bay is open to navigation all year.

ACCESSIBILITY:– It will be necessary to construct a road about 16 miles long from the northwest end of Stepovak Bay, north through the low mountains to the proposed site; no other transportation facilities are known to be present.

ELEVATION AND SURFACE CONFIGURATION:- The site is on a somewhat isolated peak that is one of two which are from 500 to 1000 feet higher than other elevations within the surrounding approximate 20 miles. The elevation of site is about 5500 or 6200 feet.

WATER SUPPLY:- Water may be procured in quantities necessary from local streams and small lakes.

NEARBY FACILITIES

Communications:- No communication facilities are available in the immediate area.

Transportation:- The Air Force and MST might operate on schedule in the area on the way to the Aleutian Islands, but landing facilities for aircraft and vessels will have to be constructed before these agencies may be utilized.

Villages:- The nearest village is Port Moller, 31 miles to the west and on the peninsula's northern coast, where the 1950 population of 33 was 19 white and 14 Indian.

ADDITIONAL REMARKS:- Temperature observations at the elevation of the proposed site have not been made in the area. Sea-level temperatures may vary from about 30°F in December to 50°F in August; the annual precipitation of roughly 60 inches will include about 30 or more inches of snow (at sea level, more at the proposed site) and a maximum in late summer and early winter; 10 to 30 per cent of the days may be cloudy, misty or foggy, with clearer days occurring in the winter months. Prevailing winds are northwest, occasionally southeast, and at the proposed site high velocities (perhaps 50 to 70 mph) should be anticipated. The possibility of earthquakes should also be anticipated.

K.H. Stone

APPENDIX 13-B

SURVEY OF ALASKAN COASTAL SITES AS GAP FILLERS

Since it was assumed that equipment changes might be necessary or desirable at existing USAF radar stations, these notes include discussion of conditions at existing sites as well as the proposal of new sites.

CAPE NEWENHAM*

Alaska Recon. Topo. Series, Hagemeister Island, 1/25,000
SW Alaska, 58° 38' N, 162° 02' W
Atop of Jagged Mountain, about 5 miles E of Cape Newenham
and less than 1 mile from NW corner of Bristol Bay

CONTINUITY OF INFORMATION LINE

Range:– 72 miles (with 300-foot tower).

Relation to Adjoining Stations:– Southeast 200 miles, across Bristol Bay to Stepovak (111-mile range; 16- to 20-mile gap, maximum altitude 200 feet, will be between the range of Cape Newenham and Stepovak; northwest 96 miles to Kwigillingok (24-mile range with 300-foot tower).

SUMMARY:– The use of this site takes advantage of an existing USAF radar base and allows the near-complete "bridging" of Bristol Bay as far west as possible in order for the Kodiak base to get as much warning time as possible. Also, the use of the site reduces (by at least 5) the number of radar stations needed to encircle Bristol Bay. BUT resupply is probably best by vessel, and such activity would be limited to May to November for unreinforced vessels, or April to December for reinforced vessels or ice breakers.

LANDING CONDITIONS

Depth, Protection, Tides:– Navigation to Cape Newenham is very likely well known by Air Force personnel resupplying the Cape Newenham station. Security Cove, about 5 miles northeast of Jagged Mt., is protected from the usual summer gales from the southeast but is open to the northwest. The bottom is even; anchorage is available in gradually shoaling water; the tidal ranges are perhaps about 10 feet; and the area may be sufficiently free of ice for unreinforced vessels to use it between about mid-May to mid-November. Good anchorage is also available in the small bight just west of Security Cove.

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*Existing USAF radar site.

Facilities:- Facilities for docking may exist for resupply of the Air Force radar station at Jagged Mt.

ACCESSIBILITY:- If facilities for docking do not exist, it will be necessary to build a road about 5 miles long from the unnamed bight (see "Facilities" above) to Jagged Mt.; no roads are presently known to exist in the area.

ELEVATION AND SURFACE CONFIGURATION:- The site is an isolated peak at least 300 feet higher than any elevation within 40 miles of it. Nevertheless, a 300-foot tower is proposed for the site in order to reduce the Cape Newenham-Stepovak gap by 4 miles and to get the maximum coverage from Jagged Mt. in case the Stepovak station must be reduced because of constructional difficulties.

WATER SUPPLY:- Water may be obtainable from the existing USAF radar station; local streams and lakes provide a source.

NEARBY FACILITIES

Communications:- The existing station probably has communication facilities to Anchorage and possibly to Kodiak.

Transportation:- The existing station is probably resupplied annually by vessel.

Villages:- The nearest village is Platinum, about 28 miles north-northeast, which had in 1950 a total population of 72 (40 white, 32 Eskimo).

ADDITIONAL REMARKS:- Bering Sea weather is quite uncertain; good weather is only occasional and winds shift frequently. In the late spring and summer it is usually mild and foggy, the winds are generally light, and there is considerable rain. After 1 September, gales are frequent and heavy fogs lessen, and by November snow accompanies storms; after December, gales are less frequent. Fog is most prevalent in spring, summer and fall, and begins to clear in October; in summer, fog may be continuous and quite thick but often only within 100 feet vertically of the water. Mean monthly temperature variations are likely to be from about 16°F in January to 55°F in July and precipitation about 25 inches annually, including 62 inches of snow.

KWIGILLINGOK

Alaska Recon. Topo. Series, Kuskokwim Bay, 1/250,000
SW Alaska, 59° 50' N, 163° 08' W
On north-central shore of Kuskokwim Bay at or near Kwigillingok village

CONTINUITY OF INFORMATION LINE

Range:– 24 miles (with 300-foot tower).

Relation to Adjoining Stations:– Southeast 96 miles to Cape Newenham (72-mile range with 300-foot tower); northwest 43 miles to Chefornak (30-mile range; Fluttar-only station).

SUMMARY:– The site would be one of the less difficult positions to reach and to carry out construction in the Kuskokwin Delta area; no roads would have to be constructed for significant distances, some local knowledge of navigational facilities will be available, and a possible supply of native labor would be at hand. BUT since maximum elevations in the area are less than 200 feet above sea level, a tower will be necessary; there are probably no landing facilities available and the approach – probably over gradually shallowing water in depths of less than 20 feet for some miles – is exposed to the stormy winds.

LANDING CONDITIONS

Depth, Protection, Tides:– Water depths of less than 20 feet possibly occur as far as 15 miles offshore and shelve gently to the shore. Any anchorage in these waters would be exposed to the full force of the winds from the southeast that usually accompany storms; the danger of being grounded by such winds would have to be anticipated. Tides are perhaps about 10 feet maximum, but in such shallow water would require the use of local knowledge to approach the shore as close as possible before lightering.

Facilities:– No facilities are known to exist, and there may be none; unreinforced vessels probably could approach the shore only between early June and early November because of ice; reinforced vessels or icebreakers may be able to extend the period by a total of 4 to 6 weeks a season, but in such shallow water the possibility may be useless.

ACCESSIBILITY:– The primary way to reach the area would be by vessel; aircraft could be used after a landing strip was built. Since the site itself must be inland (less than a mile), a short road from the landing area would be needed; no roads are present in the area.

ELEVATION AND SURFACE CONFIGURATION:- The site is a low elevation, like many nearby which are probably as high. The area is the outer, poorly drained, and low Kuskokwim River delta where elevations are 100 feet and less above sea level. Thus, a 300-foot tower is proposed to obtain some range from the site, in spite of the probable difficulty of landing it and constructing it on the unconsolidated deltaic materials of the site.

WATER SUPPLY:- Water will likely be difficult to obtain in all seasons at the site; however, the area is one of numerous lakes of all sizes and shapes, many of which perhaps are fresh.

NEARBY FACILITIES

Communications:- There is an existing non-ACS communication circuit from Kwigillingok to Bethel, about 80 miles to the northeast. At the latter, an ACS circuit extends to Anchorage.

Transportation:- No commercial or military transportation to the site is known, although small commercial vessels pass nearby in summer through Kuskokwim Bay and upstream to Bethel.

Villages:- The village of Kwigillingok had a 1950 population of 245 (6 white, 239 Eskimo).

ADDITIONAL REMARKS:- Bering sea weather is quite uncertain; good weather is only occasional and winds shift frequently. In the late spring and summer it is usually mild and foggy, the winds are generally light, and there is considerable rain. After 1 September, gales are frequent and heavy fogs lessen, and by November snow accompanies storms; after December, gales are less frequent. Fog is most prevalent in spring, summer and fall, and begins to clear in October; in summer, fog may be continuous and quite thick but often only within 100 feet vertically of the water. Mean monthly temperature variations are likely to be from about 10°F in January to 55°F in July and precipitation about 18 inches annually, including possibly 35 inches of snow.

CHEFORNAK

Alaska Recon. Topo. Series, Baird Inlet, 1/150,000
SW Alaska, 60° 05' N, 164° 16' W
On a low drainage divide about 3 miles inland from E shore of Etolin Strait, about 9 miles SSW of village of Chefornak, and about 1 mile N of triangulation point named Tern

CONTINUITY OF INFORMATION LINE

Range:– 30 miles.

Relation to Adjoining Stations:– Southeast 43 miles to Kwigillingok (24-mile range with 300-foot tower); northwest 49 miles to Cape Vancouver (49-mile range).

SUMMARY:– The site is one of the less difficult in the area from the standpoint of accessibility as well as of height in order to provide a continuous information line; no significant mileage of roads will be needed. BUT to land supplies and equipment on this coast will be difficult and will require lightering from exposed positions; the elevation of the site is low, probably less than 400 feet above sea level and perhaps less than 200 feet. Construction on the unconsolidated deltaic materials will raise some problems.

LANDING CONDITIONS

Depth, Protection, Tides:– Since the coast near the site is bordered by very shallow water and tidal flats, with 19-foot depths 5 to 7 miles offshore, it will be necessary to lighter materials ashore. The possible anchorages are unprotected from the south, from which stormy winds usually blow; tides in the locality are perhaps about 10 feet, making more necessary the use of local knowledge for navigation in the area.

Facilities:– There are no facilities for docking near the site; unreinforced vessels probably could approach the shore only between early June and early November because of ice; reinforced vessels or icebreakers may be able to extend the period by about 4 weeks a season, but in such shallow water the possibility may be useless.

ACCESSIBILITY:– It will be necessary to build a road from 3 to 5 miles long from the shore to the site. The primary method of reaching the area would be by vessel; supply by aircraft would require preliminary construction of a landing strip; no transportation facilities are available in the area.

ELEVATION AND SURFACE CONFIGURATION:– The site is a low elevation, about 400 feet above sea level on a former gravelly beach line. The area is the outer, poorly drained, and low Kuskokwim River delta; the site selected is nearly as high and as dry

as any other within at least 20 miles, which somewhat compensates for the difficult landing conditions.

WATER SUPPLY:- As much water as will be needed at an unattended station may be procured locally from ponds.

NEARBY FACILITIES

Communications:- No communication facilities are available locally.

Transportation:- No commercial or military transport to the site or area is known to be on a scheduled basis, although small coasting vessels probably pass relatively near in the summer.

Villages:- The nearest village is Chefornak, 9 miles north-northeast of the site, which in 1950 had a population of 106, all Eskimo.

ADDITIONAL REMARKS:- Bering Sea weather is quite uncertain; good weather is only occasional and winds shift frequently. In the late spring and summer it is usually mild and foggy, the winds are generally light, and there is considerable rain. After 1 September, gales are frequent and heavy fogs lessen, and by November snow accompanies storms; after December, gales are less frequent. Fog is most prevalent in spring, summer and fall, and begins to clear in October; in summer, fog may be continuous and quite thick but often only within 100 feet vertically of the water. Mean monthly temperature variations are likely to be from about 10°F in January to about 55°F in July and precipitation about 18 inches annually, including possibly 35 inches of snow.

CAPE VANCOUVER

Alaska Recon. Topo. Series, Nunivak Island, 1/250,000
W Alaska, extreme S coast, 60° 32' N, 165° 20' W
At highest elevation on upland at W extension of Nelson Island, about 2 miles E of Cape Vancouver and about 3 miles S of Tanunak landing strip

CONTINUITY OF INFORMATION LINE

Range:- 49 miles.

Relation to Adjoining Stations:- Southeast 49 miles to Chefornak (unattended; 30-mile range); north 88 miles to Cape Romanzof (68-mile range).

SUMMARY:- The site is a relatively high and exposed position on the coast; a landing strip is about 3 miles from the site, and two nearby native villages afford possible supplies of labor. BUT it may be necessary to lighter from supply vessels to the shore, and there are no docking facilities. Also, it will be necessary to construct 3 to 5 miles of road in the area, depending on the location of the landing of supplies and material.

LANDING CONDITIONS

Depth, Protection, Tides:- Tanunak Bay, on the north side of the Cape Vancouver peninsula, is the most likely place for landing of material from vessels – the water there is shallow with 18-foot depths – and it is 4 miles from Tanunak village, close to Cape Vancouver and the unnamed cape to the north; possibly the easiest landing could be made at the west end of the bay at a point near the Tanunak landing strip; the south shore of Tanunak Bay is protected from the stormy southeast winds. Possibly better landing conditions are available on the south side of the Cape Vancouver peninsula, where deeper water extends closer to the shore than on the north side; but the area is exposed to the southeast storms. A 3- to 4-mile road would still be necessary to construct, and it is likely that additional road mileage from the site to the existing landing strip would be advisable.

Facilities:- There are no docking facilities for vessels in the area; unreinforced vessels probably could reach the area only between early June and early November because of ice; reinforced vessels or icebreakers may be able to extend the period about 4 weeks. The existing landing strip may be extended relatively easily to permit landings by C-47 type aircraft.

ACCESSIBILITY:- Since there are no roads in the area, it would be necessary to construct one 3 to 5 miles long if either the north or south shore was used for landing materials. Permafrost may be present in spots to complicate the construction and maintenance of the road.

ELEVATION AND SURFACE CONFIGURATION:- Elevation of the proposed site is probably about 1200 feet, which is an exposed elevation higher than the maximum elevations on Nunivak Island (more than 35 miles southwest) but about 300 feet lower than the heights of Nelson Island (about 15 miles northeast); otherwise, land in the area is the low and poorly drained deltaic material of the Kuskokwim-Yukon delta.

WATER SUPPLY:- Water may be obtainable from a local stream system, but storage facilities will be necessary for the winter season when local water bodies are frozen.

NEARBY FACILITIES

Communications:- A non-ACS communication circuit extends from Tanunak village to Bethel.

Transportation:- Small vessels probably pass along the coast near Cape Vancouver in the summer; otherwise, no commercial or military transport to the area is known to be on a scheduled basis.

Villages:- Tanunak village, about 5 miles northeast of the proposed site, had a 1950 population of 112 (3 white, 109 Eskimo). Also, Umkumute village (about 10 miles east of the site) had in 1950 a population of 99, all Eskimo.

ADDITIONAL REMARKS:- Bering sea weather is quite uncertain; good weather is only occasional and winds shift frequently. In the late spring and summer it is usually mild and foggy, the winds are generally light, and there is considerable rain. After 1 September, gales are frequent and heavy fogs lessen, and by November snow accompanies storms; after December, gales are less frequent. Fog is most prevalent in spring, summer and fall, and begins to clear in October; in summer, fog may be continuous and quite thick but often only within 100 feet vertically of the water. Mean monthly temperature variations are likely to be from about 10°F in January to about 55°F in July and precipitation about 17 inches annually, including possibly 35 inches of snow.

CAPE ROMANZOF

Alaska Recon. Topo. Series, Hooper Bay, 1/250,000
W Alaska, 61° 46' N, 165° 52' W
At highest elevation in Askinuk Mountains, about
8 miles ESE of Cape Romanzof

CONTINUITY OF INFORMATION LINE

Range:- 68 miles.

Relation to Adjoining Stations:- South 88 miles to Cape Vancouver (49-mile range); northwest 142 miles to Northeast Cape, St. Lawrence Island (59-mile range with 300-foot tower); Romanzof-Northeast coverage leaves a 15-mile 100-foot altitude gap near middle which could be employed only by offending aircraft flying around south side of St. Lawrence Island and thence northeast through the gap, in coverage at a very low altitude.

SUMMARY:- The site is the location of an existing USAF radar site where facilities for landing and for operation are already present; the position of the station is high and exposed. BUT supply by unreinforced vessels would likely be limited to about 4 months. If the existing base is at the 1500-foot elevation at Cape Romanzof (rather than at the 2363-foot peak on the east), it will be necessary to build about 8 miles of road to the peak, as well as to the other installations, for a low-coverage station.

LANDING CONDITIONS

Depth, Protection, Tides:- Knowledge of local conditions for navigation is likely, as a result of installing and supplying the existing USAF station. At Windy Cove, just northeast of Cape Romanzof, 18-foot depths are a mile or less offshore, and the coast there and on the east is hardened by abrupt cliffs and hills; yet the cove is protected from stormy southerly winds. At the positions just west of Cape Romanzof, vessels would be exposed to the west, north and south, and depths are shallower; tides are about 5 feet in the area and might cause difficulty in the very shallow water adjoining the northern coast of the Askinuk Mts. to the east of Pt. Smith.

Facilities:- There may be docking facilities (in conjunction with the existing USAF station) that are free of ice and open to unreinforced vessels from about mid-June until about late October.

ACCESSIBILITY:- There may be an existing road system in conjunction with the present USAF station which would be sufficient, unless the existing site is at the 1500-foot rather than the 2363-foot elevation.

ELEVATION AND SURFACE CONFIGURATION:- The 2363-foot elevation is at least 800 feet higher than any land within 125 miles of the site. The Askinuk Mts. are a small isolated range in the otherwise flat and low, poorly drained Yukon-Kuskokwim River delta.

WATER SUPPLY:- Water may be obtainable in sufficient quantity from the existing USAF station facilities; otherwise, short local streams may be used in summer.

NEARBY FACILITIES

Communications:- The existing USAF station conceivably has regular communication with Fairbanks military installations and possibly with those in Anchorage.

Transportation:- Commercial vessels operate in the 4 summer months to points along the western Alaskan coast on a schedule of about once a month.

Villages:- Northeast of the 2363-foot peak is Scammon Bay village which, in 1950, had a population of 103 (all Eskimo). South-southwest nearly 20 miles is Hooper Bay, a village of 307 people in 1950 (4 white, 303 Eskimo).

ADDITIONAL REMARKS:- Bering Sea weather is quite uncertain; good weather is only occasional and winds shift frequently. In the late spring and summer it is usually mild and foggy, the winds are generally light, and there is considerable rain. After 1 September, gales are frequent and heavy fogs lessen, and by November snow accompanies storms; after December, gales are less frequent. Fog is most prevalent in spring, summer and fall, and begins to clear in October; in summer, fog may be continuous and quite thick but often only within 100 feet vertically of the water. Mean monthly temperature variations are likely to be from about 5° F in January to 50° F in July and August and precipitation about 15 inches annually, including possibly 50 inches of snow.

NORTHEAST CAPE

Alaska Recon. Topo. Series, St. Lawrence, 1/150,000
E St. Lawrence Island, Bering Sea, 63° 17' N, 168° 48' W or 168° 59' W
Atop either 1435-foot elevation or 1462-foot elevation, 3-1/2 and 8-1/2 miles, respectively, W of Cape Seevooka; the specific site being the location of existing USAF station

CONTINUITY OF INFORMATION LINE

Range:– 59 miles (with 300-foot tower).

Relation to Adjoining Stations:– Southeast 142 miles to Romanzof (69-mile range); Romanzof-Northeast Cape coverage leaves a 15-mile 100-foot altitude gap near the middle which could be used only by offending aircraft flying around the south side of St. Lawrence Island and thence northeast through the gap, in coverage at a low altitude (less than about 100 feet); northeast 138 miles to Tisuk (83-mile range).

SUMMARY:– The site is that of an existing USAF radar site and where, therefore, facilities for landing and for operation are already present. The site is sufficiently high and exposed to have the advantage of this part of the line having more than 100 miles west of the mouth of Norton Sound and to exclude the necessity of at least 3 more stations to cross Norton Sound. BUT supply by unreinforced vessels may be limited to about 3 to 4 months, and the landing of materials might be difficult; permafrost should be anticipated on land.

LANDING CONDITIONS

Depth, Protection, Tides:– Knowledge of local navigational conditions is likely, as a result of the installation and supply of the existing USAF station. South of Cape Seevooka, the 6-fathom line is 3/4 to 1 mile offshore; west of Cape Seevooka there are rocks and shallow water offshore from a low sand beach; however, it has shelter from southerly winds, whereas the coast south of Cape Seevooka is exposed to these possible stormy winds. Tides in the area are about 2 feet, and are unlikely to cause difficulties.

Facilities:– There may be docking facilities in conjunction with the existing USAF station, unless supply since installation has been entirely by air (the Northeast Cape landing strip was closed, at least to civilian traffic in June 1953); if unreinforced vessels are used, they are likely to find the area free of ice only for the period of about mid-July to the end of October.

ACCESSIBILITY:– There is probably an existing road system in conjunction with the USAF station; permafrost may make its maintenance difficult.

ELEVATION AND SURFACE CONFIGURATION:- The 1435-foot elevation with a 300-foot tower would be at least 270 feet higher than any elevation within at least 40 miles; general elevations of the eastern highland of St. Lawrence Island are 600 to 1000 feet, and the 1462-foot peak is the highest in the eastern half of the island.

WATER SUPPLY: Water may be obtainable in sufficient quantity from the existing USAF station facilities; otherwise, there are several short streams and fresh water lakes near the site which may be used in summer.

NEARBY FACILITIES

Communications:- The existing USAF station presumably has regular communication with Fairbanks military installations, and possibly with those in Anchorage.

Transportation:- Commercial vessels operate to Nome about once a month in 4 summer months, and service other western Alaskan points.

Villages:- The village of Savoonga, about 60 miles northwest of the site, is the nearest settlement; in 1950, the village had 249 people (3 white, 246 Eskimo).

ADDITIONAL REMARKS:- Bering sea weather is quite uncertain; good weather is only occasional and winds shift frequently. In the late spring and summer it is usually mild and foggy, the winds are generally light, and there is considerable rain. After 1 September, gales are frequent and heavy fogs lessen, and by November snow accompanies storms; after December, gales are less frequent. Fog is most prevalent in spring, summer and fall, and begins to clear in October; in summer, fog may be continuous and quite thick but often only within 100 feet vertically of the water. Mean monthly temperature variations are likely to be from about 0°F in January to 50°F in July and precipitation about 13 inches annually, including about 60 inches of snow; winds are predominantly from the north.

TISUK

Alaska Recon. Topo. Series, Nome, 1/250,000
SW Seward Peninsula, 64° 54' N, 166° 05' W
Atop of 3600-foot elevation at W end of
Kigluaik Mts. and between lower Tisuk
and Sinuk Rivers

CONTINUITY OF INFORMATION LINE

Range:- 83 miles.

Relation to Adjoining Stations:- Southwest 138 miles to Northeast Cape (59-mile range); northwest 73 miles to Wales (67-mile range) or north 103 miles to Kividlow (24-mile range with 300-foot tower).

SUMMARY:- The site is high and exposed, making possible overlapping coverage between Northeast Cape and Tisuk, as well as Kividlow and Tisuk. BUT it is likely to be difficult to get supplies and equipment to the site during the 3-month open season; landing will probably require lightering. A road about 12 miles long will have to be built – the first part over low swampy land, the last in steep mountainous slopes; and permafrost should be anticipated. However, the advantages of the site outweigh the costs of conquering these difficulties.

LANDING CONDITIONS

Depth, Protection, Tides:- The approach to the shore between Cape Rodney on the southeast and Cape Douglas on the northwest must be done with great care. This approach is exposed to the south and west, and the water is shallow with dangerous shoals and ledges at Cape Rodney; 18-foot depths are about 1 mile offshore, but off the break in the bar between Capes Rodney and Douglas, the 18-foot depths are possibly 5 to 8 miles offshore; tides are 1 to 2 feet in the area. Perhaps it would be easier to attempt landing near Cape Woolley, but there are rocks northwest of the Cape; the inshore swamp area is inside (3 to 4 miles); and the road would have to be about 18 miles long, with at least two moderately long and strong bridges. It is considered wiser to attempt to pass through the bar between Capes Rodney and Douglas, or northeast over the lagoon and to the shore, behind which is a swampy strip about 1 to 2 miles wide.

Facilities:- No facilities for docking are on this coast; it is free of ice for navigation by unreinforced vessels between late June and mid-October, but the shallowness and freshness of the lagoon probably make the season there no longer than 3-1/2 to 4 months. Consideration should be given to using the ice rather than waiting for it to break up; landing of materials might be easier from an ice-breaker (in May or June) approaching as close as possible and unloading onto the ice. Transportation inshore

and overland could be by land-type vehicles, which would make lightering unnecessary and might be much easier across the swampy area just inshore from the lagoon.

ACCESSIBILITY:- There are no transportation facilities in the area, and it would be difficult to reach it by any means except by air from Nome (about 35 miles southeast) after a landing strip was built at the site. However, difficulty in the maintenance of roads and air strips in an area of permafrost should be anticipated.

ELEVATION AND SURFACE CONFIGURATION:- The site is proposed at the top of a 3600-foot peak at the west end of the Kigluaik Mts.; this is the highest elevation within about 20 miles. South and west of the proposed site, elevations are 100 to 2000 feet in low mountains; to the southwest, elevations drop sharply to about 500 feet and thence gradually to sea level; to the northeast are the main peaks of the Kigluaik Mts. which reach a minimum height 25 miles from the proposed site.

WATER SUPPLY:- Water should be available locally in sufficient quantity in summer from the local streams and a few small lakes; storage for the winter period will be necessary.

NEARBY FACILITIES

Communications:- No communication facilities are present in the area.

Transportation:- No transportation facilities are present in the area. Movement by sea or land to the area will be limited to the summer months when thawing permafrost may cause problems; overland transport will be easier in winter when the swamps and streams are frozen.

Villages:- The nearest settlements are Teller (27 miles north-northwest), which had a 1950 population of 160 (35 white, 125 Eskimo) and Nome (35 miles southeast), which had a 1950 population of 1876 (945 white, 927 Eskimo, 4 other).

ADDITIONAL REMARKS:- Bering Sea weather is quite uncertain; good weather is only occasional and winds shift frequently. In late spring and summer it is usually mild and foggy, the winds are generally high, and there is considerable rain. After 1 September, gales are frequent and heavy fogs lessen, and by November snow accompanies storms; after December, gales are less frequent. Fog is most prevalent in spring, summer and fall, and begins to clear in October; in summer, fog may be continuous and quite thick but often only within 100 feet vertically of the water. Mean monthly temperature variations are likely to be, at sea level near the site, from about 0°F in January to 50°F in July and August; annual precipitation is about 17 inches, including about 60 inches of snow. Winds are predominantly from the northeast, with average monthly velocities from 7 to 10 mph.

WALES*

Alaska Recon. Topo. Series, Teller, 1/250,000
W tip of Seward Peninsula, 65° 35' N, 168° 0' W
Atop Cape Mountain about 3 miles SE of Wales
village and 2-1/2 miles NW of Tin City village

CONTINUITY OF INFORMATION LINE

Range:– 67 miles.

Relation to Adjoining Stations:– Southeast 73 miles to Tisuk (83-mile range); northeast 87 miles to Kividlow (24 miles with 300-foot tower).

SUMMARY:– The site is not essential for continuous low information, but offers the advantage of providing information for more than 50 miles farther west than from Tisuk; it is noted here only as a possibility because of this extension of coverage and because it is an existing USAF radar station on a high and exposed site. BUT while landing of supplies and equipment from vessels may be difficult, much resupply may be by air from nearby landing strips.

LANDING CONDITIONS

Depth, Protection, Tides:– Knowledge of local navigational conditions is likely available from units that have been supplying the existing station. The water shoals gradually shelve offshore from Tin City, reaching 30-foot depths in about 2/3 mile, tides are of little concern, being one or two feet, but the exposure to the southeast-southwest makes any anchorage open to stormy winds.

Facilities:– Landing facilities may exist in conjunction with the existing USAF station. Unreinforced vessels are likely to be limited by ice from the period of mid-July to late September or early October.

ACCESSIBILITY:– A local road system may be maintained for the existing USAF station.

ELEVATION AND SURFACE CONFIGURATION:– Cape Mountain, the site of the existing USAF station is 2300 feet high – the highest part of the knob-like westward extension of the York Mountains, and the highest elevation within at least 18 miles. The nearest elevations of about 1000 feet above sea level are more than 13 miles to the east and northeast.

WATER SUPPLY:– Water is presumably available at the existing USAF station.

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*Existing AAC radar site.

NEARBY FACILITIES

Communications:- The existing USAF station should have direct and regular communication with military bases at Fairbanks and Anchorage. In addition, a non-ACS circuit connects Wales village with Nome, where ACS circuits run to both Fairbanks and Anchorage.

Transportation:- No transportation facilities are available other than the probable local road system, and two landing strips - one 4 miles east of Cape Mt., and the other about 3 miles northwest of Cape Mt. on the beach just north of Wales. Alaska Airlines has regularly scheduled flights from Nome to Wales once a week.

Villages:- Wales village, nearly 3 miles northwest of the site, had a 1950 population of 141 (2 white, 139 Eskimo); the Tin City village population is probably less than 25.

ADDITIONAL REMARKS:- Bering Sea weather is quite uncertain; good weather is only occasional and winds shift frequently. In late spring and summer it is usually mild and foggy, the winds are generally light, and there is considerable rain. After 1 September, gales are frequent and heavy fogs lessen, and by November snow accompanies storms; after December, gales are less frequent. Fog is most prevalent in spring, summer and fall, and begins to clear in October; in summer, fog may be continuous and quite thick but often only within 100 feet vertically of the water. Mean monthly temperature ranges are likely to be from −2°F in March to 48°F in August; annual precipitation is about 15 inches, including probably about 40 inches of snow. Winds are predominantly from the north, with average monthly velocities of 10 to 20 mph.

KIVIDLOW

Alaska Recon. Topo. Series, Shishmaref, 1/125,000
NW coast of Seward Peninsula, 66° 19' N, 165° 43' W
On offshore bar about 3 miles NE of settlement site of Kividlow or about 13 miles NE of Shishmaref village

CONTINUITY OF INFORMATION LINE

Range:- 24 miles (with 300-foot tower).

Relation to Adjoining Stations:- Southwest 87 miles to Wales (67-mile range) or south 103 miles to Tisuk (83-mile range); northeast 80 miles to Tikizat (55-mile range).

SUMMARY:- The site is an essential position in order to provide continuous low coverage between Tisuk and Tikizat, or Wales and Tikizat. BUT the landing of materials at the site will be difficult and, perhaps, will be limited to a 2-month open season for navigation; the problem of permafrost should be anticipated in construction and maintenance. A tower, at least 300 feet high, is essential to provide the continuous coverage at the near sea-level elevations; water supply will be a further problem.

LANDING CONDITIONS

Depth, Protection, Tides:- The offshore area is very shallow and lightering will be necessary; the 60-foot depths are 15 to 20 miles offshore. Anchorages at these points are exposed to the north and south to southwest winds usually accompanying storms in the area. Changes in water level accompanying strong winds are likely to be more significant than the 2- to 3-foot tides in the area.

Facilities:- No landing facilities are present in the area. The open navigation season for unreinforced vessels is, on the average, from mid-July to mid-September. When water is so shallow, it is useful to unload freight from reinforced vessels or ice-breakers onto ice and thence move it onshore; but the usefulness of this technique here is questionable because of the possibility of the vessel being caught in the ice and forced to winter through. Materials might also be brought by barge and beached without lightering in good weather.

ACCESSIBILITY:- The area is accessible primarily by sea, but it could be reached by aircraft once a suitable landing strip was constructed.

ELEVATION AND SURFACE CONFIGURATION:- The site is an offshore bar, with probable maximum elevations of about 30 feet above sea level; the bar is less than a mile wide on the average, is backed by a shallow lagoon. Farther southeast the lagoon is backed by at least 25 miles of sea-level swamp, and the coastal region is the same for more than 50 miles either to the northeast or southwest. The site must be located either as described, or within 3 miles to the northeast in order to provide the continuous low coverage with or without the possible Wales station.

WATER SUPPLY:- Water supply is likely to be a problem in the area. Either sea water will have to be distilled, or sea ice collected, melted and distilled, if local sources are to be used.

NEARBY FACILITIES

Communications:- A non-ACS communication circuit links Shishmaref with Nome.

Transportation:- Alaska Airlines has regularly scheduled flights once a week from Nome to Shishmaref; otherwise, no transportation facilities are available in the area.

Villages:- Shishmaref village, 13 miles southwest and nearest to the site, had a 1950 population of 194 (7 white, 187 Eskimo).

ADDITIONAL REMARKS:- In general, the Alaskan shore north of Bering Strait is shallow, and depths must be noted carefully and constantly when navigation is less than approximately 10 miles from the shore; native guidance may be useful for such inshore navigation. In general, the Bering Strait is ice-free by the first week in July, but clear water does not extend far northward. It is seldom possible for unreinforced vessels to get as far north as Point Hope before 10 to 15 July. With easterly and southerly winds, however, the coast tends to be open; and with westerly and northerly winds, pack ice is usually blown in toward shore, particularly if these winds are prolonged and in spite of a generally northward current of 1 knot alongshore.

During early summer the weather of the northwest Alaskan coast is usually light with much fog and rain; the occasional gales at this time of year are severe and from the southwest. Later in the summer, gales are frequent and more generally from the north; September and October are the windiest months, when the monthly average velocities approximate 15 mph, compared with the average of 10 mph for other months. The prevailing direction along the coast described herein is from the north except where locally modified by relatively high relief of the surface.

Inasmuch as the northwest Alaskan coast is near or north of the Arctic Circle, daylight is continuous during about 80 days of May, June and July; however, the sun is low, freezing temperatures may occur in any month, and the presence of fog or clouds may contribute to personnel feeling the relatively low temperatures. With increasing distance inland there is less likelihood of fog and the probability of higher temperature ranges in the lower elevations. Precipitation in the northwest Alaskan coastal area is light in total, heaviest in July, August and September; the snow cover generally disappears in May and returns in September.

At Kividlow, mean monthly temperatures are likely to vary from 6°F in February to 47°F in July and August. Annual precipitation is about 7 inches, including about 34 inches of snowfall.

TIKIZAT

Alaska Recon. Topo. Series, Noatak, 1/250,000
NW Alaskan coast, at N side of entrance to Kotzebue Sound, 67° 09' N, 163° 30' W
Atop approximately 1500-foot elevation about 7 miles ENE of Cape Krusenstern and about 6 miles SE of village site of Tikizat

CONTINUITY OF INFORMATION LINE

Range:- 55 miles (may need tower to obtain this).

Relation to Adjoining Stations:- Southwest 80 miles to Kividlow (24-mile range with 300-foot tower); northwest 86 miles to Seppings (48-mile range).

SUMMARY:- The site is at an exposed elevation which (perhaps with the addition of a tower) provides sufficient elevation to maintain continuous low-altitude coverage along the coast between the Kividlow and Seppings sites; water is probably obtainable locally in summer. BUT although the landing of materials at the site is likely to be less difficult than at Kividlow and only moderately difficult for the area, it will be limited to a 2-month open season for navigation; continuous permafrost throughout the area should be anticipated in construction and maintenance, and a tower may be necessary, as well as a 9-mile road.

LANDING CONDITIONS

Depth, Protection, Tides:- The 18-foot depth line is about 1 mile offshore from the beach west of Tikizat village site. The anchorage is unprotected to the west but close inshore; and there would be some protection from northerly, easterly and southerly winds. The beach is very likely loose gravel and shingle rock; tides are about 2 feet, and not particularly bothersome for small vessel landings.

Facilities:- There are no known docking facilities at the coast nearest the proposed site; materials would have to be lightered ashore a short distance, or brought on barges that could be pushed directly to the beach. The open navigation season is from about mid-July to mid-September for unreinforced vessels.

ACCESSIBILITY:- The area is accessible primarily by sea, but could be reached by aircraft once a suitable landing strip was constructed; otherwise, only a winter trail runs along the beach. Consequently, a road about 9 miles long will have to be built from the beach east-southeast to the site.

ELEVATION AND SURFACE CONFIGURATION:- The site is on the highest elevation within 7 miles to the east and north, and greater distances south and southwest. The

exact height of the peak is unknown and should be determined to find out if a tower is required to reach the 1500-foot elevation necessary to overlap with the Kividlow station.

WATER SUPPLY:- Water is likely obtainable locally from streams and lakes in the summer; water from the large lagoon between Cape Krusenstern and the site should be distilled to be potable.

NEARBY FACILITIES

Communications:- No existing communication facilities are present.

Transportation:- No scheduled airline operation exists to the site, but it could be served by Wien-Alaska Airlines from their base at Nome.

Villages:- Tikizat is a small Eskimo village of less than 25 people. Noatak, 32 miles east-northeast, had a 1950 population of 326 (1 white, 325 Eskimo) and Kotzebue, 32 miles southeast of the site, had a 1950 population of 623 (69 white, 554 Eskimo).

ADDITIONAL REMARKS:- Bering Sea weather is quite uncertain; good weather is only occasional and winds shift frequently. In the late spring and summer it is usually mild and foggy, the winds are generally light, and there is considerable rain. After 1 September, gales are frequent and heavy fogs lessen, and by November snow accompanies storms; after December, gales are less frequent. Fog is most prevalent in spring, summer and fall, and begins to clear in October; in summer, fog may be continuous and quite thick but often only within 100 feet vertically of the water. At Tikizat mean monthly temperatures are likely to range from -10°F in January to 52°F in July; annual precipitation is about 6 inches, including about 47 inches of snowfall.

CAPE SEPPINGS

Alaska Recon. Topo. Series, Point Hope, 1/250,000
NW Alaskan coast, 68° 07' N, 165° 31' W
Atop approximately 1185-foot peak 3-1/2 miles inland from shore at point about 11 miles SE of Cape Thompson

CONTINUITY OF INFORMATION LINE

Range:– 48 miles.

Relation to Adjoining Stations:– Southeast 86 miles to Tikizat (55-mile range; perhaps with tower); north-northwest 53 miles to Cape Lisburne (45-mile range).

SUMMARY:– The site is at an exposed elevation that provides sufficient elevation to maintain continuous low-altitude coverage along the coast between Tikizat and Cape Lisburne; water may be obtainable locally in the summer. BUT landing of materials would be moderately difficult for the area during a 1-1/2- to 2-month open navigation season; continuous permafrost throughout the area should be anticipated in construction and maintenance.

LANDING CONDITIONS

Depth, Protection, Tides:– Since 18-foot depths are between 1/3 to 1/4 mile offshore, landings by small vessels or barges in the open season should be moderately easy. The anchorage is exposed to the southwest and south, but is protected to the north by the shore and inland hills. The beach is very likely loose gravel and shingle rock, and narrow with slopes rising evenly to about 500 feet above sea level within about 1/2 mile of the point of suggested landing; tides are about 2 feet in the area, and would have little effect on the landing.

Facilities:– There are no docking facilities in the area, but materials might be landed from small vessels directly onshore, or might be brought on barges that could be pushed directly to the beach. The open navigation season is from about mid-July to mid-September (at the longest) for unreinforced vessels.

ACCESSIBILITY:– The area is accessible primarily by sea, but it could be reached by aircraft once a suitable landing strip was constructed; otherwise, only a winter trail runs along the beach. Consequently, a road about 4 miles long would have to be built from the beach inland (north).

ELEVATION AND SURFACE CONFIGURATION:– The site is the highest elevation (1185 feet) within at least 12 miles in any direction; it is 400 to 600 feet above the elevation of most of the surrounding land.

WATER SUPPLY:- Water is likely to be obtainable from several nearby streams in summer.

NEARBY FACILITIES

Communications:- No communication facilities are available at the site at present.

Transportation:- No scheduled airline operations exist to the site, but it could be served by Wien-Alaska Airlines from their base in Nome, or by the USAF supplying the existing station at Cape Lisburne.

Villages:- There are no Eskimo villages in the immediate area of the site.

ADDITIONAL REMARKS:- In general, the Alaskan shore north of Bering Strait is shallow, and depths must be noted carefully and constantly when navigation is less than approximately 10 miles from the shore; native guidance may be useful for such inshore navigation. In general, the Bering Strait is ice-free by the first week in July, but clear water does not extend far northward. It is seldom possible for unreinforced vessels to get as far north as Point Hope before 10 to 15 July. With easterly and southerly winds, however, the coast tends to be open; and with westerly and northerly winds, pack ice is usually blown in toward shore, particularly if these winds are prolonged and in spite of a generally northward current of 1 knot alongshore.

During early summer the weather of the northwest Alaskan coast is usually light with much fog and rain; the occasional gales at this time of year are severe and from the southwest. Later in the summer, gales are frequent and more generally from the north; September and October are the windiest months, when the monthly average velocities approximate 15 mph, compared with the average of 10 mph for other months. The prevailing direction along the coast described herein is from the north except where locally modified by relatively high relief of the surface.

Inasmuch as the northwest Alaskan coast is near or north of the Arctic Circle, daylight is continuous during about 80 days of May, June and July; however, the sun is low, freezing temperatures may occur in any month, and the presence of fog or clouds may contribute to personnel feeling the relatively low temperatures. With increasing distance inland there is less likelihood of fog and the probability of higher temperature ranges in the lower elevations. Precipitation in the northwest Alaskan coastal area is light in total, heaviest in July, August and September; the snow cover generally disappears in May and returns in September.

At Seppings, mean monthly temperatures may range from about –17°F in January to 50°F in July; annual precipitation is about 6 inches, including about 47 inches of snowfall.

CAPE LISBURNE*

Alaska Topo. Recon. Series, Point Hope, 1/250,000
Extreme NW Alaskan coast, 68° 52' N, 166° 11' W
Atop of peak about 1 mile ESE of Cape Lisburne

CONTINUITY OF INFORMATION LINE

Range:- 45 miles.

Relation to Adjoining Stations:- South-southeast 53 miles to Seppings (48-mile range); east and northeast, low-altitude coverage extended by Corrode line.

SUMMARY:- The site is at an existing USAF radar installation where problems of construction and supply have been experienced. BUT the open season for vessels in the area is about 1-1/2 to 2 months long; continuous permafrost throughout the area should be anticipated in construction and maintenance.

LANDING CONDITIONS

Depth, Protection, Tides:- 18-foot depths are close inshore, and Cape Lisburne forms a rugged headland on the coast. Vessels should keep well off the Cape during the strong local winds that are common in this part of the Lisburne Hills. Tides are probably 1 to 2 feet and are not significant with regard to landing. Anchorages are exposed: the west part of the Cape is open to the north, south and west, and the east is unprotected to the north, east and west. Much knowledge about local navigational conditions may be available from the USAF agency resupplying the existing station.

Facilities:- Docking facilities may have been constructed in conjunction with the existing USAF station; a small landing strip lies about 4-1/2 miles east of the Cape near the north shore. The open navigation season is from about mid-July to mid-September for unreinforced vessels.

ACCESSIBILITY:- The area is accessible primarily by sea or by small aircraft; otherwise, a winter trail runs along the beach. A small local road system may be present for the existing USAF radar station.

ELEVATION AND SURFACE CONFIGURATION:- The site is at about the same elevation as the mid-slopes of the Lisburne Hills, which rise to Mt. Hamlet, 8 miles southeast of the site and more than 2000 feet high.

WATER SUPPLY:- Water may be obtainable from the existing USAF station.

NEARBY FACILITIES

Communications:- The existing USAF station should have direct communication with military installations in Fairbanks and Anchorage.

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*Existing USAF radar site.

Transportation:– The USAF very likely operates a series of resupply and maintenance flights to the existing stations. Wien-Alaska Air-lines operates from Nome through the area, but has no scheduled landings at the Cape.

Villages:– No native village is in the area of the station. However, modification of the station to add low-altitude coverage should not require much native labor.

ADDITIONAL REMARKS:– In general, the Alaskan shore north of Bering Strait is shallow, and depths must be noted carefully and constantly when navigation is less than approximately 10 miles from the shore; native guidance may be useful for such inshore navigation. In general, the Bering Strait is ice-free by the first week in July, but clear water does not extend far northward. It is seldom possible for unreinforced vessels to get as far north as Point Hope before 10 to 15 July. With easterly and southerly winds, however, the coast tends to be open; and with westerly and northerly winds, pack ice is usually blown in toward shore, particularly if these winds are prolonged and in spite of a generally northward current of 1 knot alongshore.

During early summer the weather of the northwest Alaskan coast is usually light with much fog and rain; the occasional gales at this time of year are severe and from the southwest. Later in the summer, gales are frequent and more generally from the north; September and October are the windiest months, when the monthly average velocities approximate 15 mph, compared with the average of 10 mph for other months. The prevailing direction along the coast described herein is from the north except where locally modified by relatively high relief of the surface.

Inasmuch as the northwest Alaskan coast is near or north of the Arctic Circle, daylight is continuous during about 80 days of May, June and July; however, the sun is low, freezing temperatures may occur in any month, and the presence of fog or clouds may contribute to personnel feeling the relatively low temperatures. With increasing distance inland there is less likelihood of fog and the probability of higher temperature ranges in the lower elevations. Precipitation in the northwest Alaskan coastal area is light in total, heaviest in July, August and September; the snow cover generally disappears in May and returns in September.

At Cape Lisburne, mean monthly temperatures probably range from about –12°F in January to about 47°F in July; annual precipitation is about 5 inches, including about 40 inches of snowfall.

K.H. Stone

APPENDIX 13-C

SOME POSSIBLE LOCATIONS FOR VERY LONG FLUTTAR LINKS

Fluttar links now being planned as in the DEW and Mid-Canada lines are about 50 or 60 miles long. Elsewhere in the Lamp Light report, much longer links – up to 300 miles in length and from both elevated and low terminals – are considered. In the eastward extension of the DEW line from Baffin Island to the United Kingdom, jumps between land-sited radars are nearly as long and, generally speaking, high-altitude sites are available so that the terminals are not far below line-of-sight from each other. Communications between these radar sites will presumably be of the form of tropospheric-scatter links with low-frequency, high-frequency ground-wave, or JANET (meteoric) back-up.

It is urged that studies be undertaken to examine the feasibility of Fluttar detection links between these radar stations, including the possibilities of deriving Fluttar signals from the communication circuits. In addition to the possible enhancement in low-altitude cover due to the high values of forward-scattering cross section as an aircraft crosses the line between the stations, it appears that the variations in scattering cross section with scattering angle are characteristic of various aircraft, and thus aircraft "signatures" are available. Even for aircraft within line-of-sight from one or the other radar station, a comparison of radar and Fluttar signals will help in the counting and identification problems.

For some links and certain frequencies, the direct or reference signal may be too low for good Fluttar operation, and techniques should be explored to find methods of supplying a suitable reference signal as, for example, by local generation or transmission on some other (harmonically) related frequency. It would then be possible to choose the link parameters for most suitable reflection characteristics without any need to obtain high levels of reference signal. It should be noted, however, that the reference signal is usually too high, not too low.

Among the factors requiring study are the noise characteristics of tropospheric-scatter signals in the range of frequency of the Fluttar signals and the variations of these with the depth below free-space transmission signal levels. A series of experiments of great value could be run between the proposed radar stations on the eastward extension of the DEW line from Baffin Island to the United Kingdom. Earlier experiments might be more conveniently carried out between the Gaspé Peninsula in Quebec and either Cape North on Cape Breton Island or Cape Ray in Newfoundland. The Magdalen Islands are conveniently located near the center of these links.

In the following list of links from Baffin Island to the United Kingdom, certain high sites were picked from small-scale maps (1:1,000,000) without regard for logistics, and the size of the tunnels left under radar coverage from each end was calculated for 4/3 earth's radius. Crude computations based on ordinary ground-wave propagation theory were made for direct-path transmission over these links for frequencies from 20 to 200 Mcps. The results ranged from 40 or 50 db below free space to nearly 200 db below free space for the longest link and the highest frequency. It is to be expected, of course, that tropospheric-scatter transmission would predominate over ground-wave transmission at these distances of about 250 miles when the ground-wave signal is more than 80 db below free space. Similarly crude calculations were made for the reflected signal from a target in the "tunnel" for an assumed scattering cross section of 100 m^2, a value which might easily be 30 or 40 db too low. Aircraft scatter signals were calculated to be 160 to 180 db below nonreflected free-space signals for cases where the aircraft was in the middle of the tunnel and at altitudes as low as 100 feet. From these computations it appeared fairly simple to select, for each link and for each low aircraft altitude, a frequency where the direct (or scatter) path signal would exceed the aircraft reflected signal by between 60 and 100 db. Lincoln Laboratory has found that, on a 150-mile link, useful Fluttar signals have been obtained for values of this reference signal to aircraft signal ratio between 40 and 100 db. These computations have not been examined in more detail and are not given here because of the rough choice of terminals. The choice of terminals will be dictated by radar requirements and, once chosen, Fluttar-link calculations should be repeated.

Possible Long Fluttar Links

Baffin Island – Greenland (245 n. mi.)

Terminals: Cape Dyer (3500 ft) and Holsteinborg (5000 ft)
Radar horizons: 73 and 87 n. mi.
Gap at surface: 85 n. mi.
Height of tunnel: 1200 ft

Greenland – Iceland (200 n. mi.)

Terminals: 8500 and 3000 ft
Radar horizons: 113 and 67 n. mi.
Gap at surface: 20 n. mi.
Height of tunnel: 70 ft

Iceland – Faroes (280 – 285 n. mi.)

Terminals: 6000 and 3000 ft
Radar horizons: 95 and 66 n. mi.
Gap at surface: 124 n. mi.
Height of tunnel: 2500 ft

Faroes – Shetland (185 n. mi.)

Terminals: 3000 and 1500 ft
Radar horizons: 66 and 48 n. mi.
Gap at surface: 71 n. mi.
Height of tunnel: 800 ft

R.S. Rettie

APPENDIX 13-D
INVESTIGATION OF POSSIBLE WARNING LINE IN QUEEN ELIZABETH ISLANDS AND NORTHERN GREENLAND

ABSTRACT

With the knowledge that a number of new radar sites had been requested for the early warning and air defense of Thule Air Force Base, an investigation was made of the feasibility of tying such stations in with the DEW line and with the proposed Baffin Island – United Kingdom extension. It was concluded that high cover could be obtained by placing "Sentinel" radars at certain of the Joint Weather Stations.

QUEEN ELIZABETH ISLANDS

A possible line of radar sites on the northern perimeter of the Queen Elizabeth Islands was investigated. It was felt that such a line to provide both high and low cover could be established. However, its installation and maintenance would be difficult and expensive.

The primary advantages of the most northerly line are:

This position is the most northerly possible for land-based installations,

The experiences and facilities of the Joint Weather Stations at Mould Bay, Isachsen, Eureka, and Alert may be used,

The line could be extended eastward across northern Greenland at the same high latitude of northern Ellesmere (without a reentrant),

The highlands of inner Axel Heiberg and Ellesmere Island would aid detection by forcing possible offenders to fly at minimum elevations of 3000 to 5000 feet.

Disadvantages of the most northerly line are:

Probable necessity of installation and resupply by air,

Climatic hazards of operation,

Inadequate local water supplies at several sites,

Necessity of very careful placement of installations to insure completeness of coverage over low land and water gaps in the central areas,

Possibility of ground clutter because of the nature of the coastal terrain of most of northern Ellesmere Island.

On balance it was felt that the provision of complete high and low coverage was not justified.

However, to provide a line secure against high-altitude penetration (above 25,000 feet) is relatively simple because of the presence of the existing Joint Canadian-U.S. Weather Stations and the DEW site to be established by Western Electric Company at Cape Parry. With the existence of the DEW line (tight against 200 feet penetration) low coverage in this extension is not so important if it can detect high-altitude, high-speed raids. The expected coverage against high-altitude flight by planes of B-47 size is shown in Fig. 13-4 in Chap. 13. This proposes the placement of Sentinel type radars at

Cape Parry (DEW site)
Mould Bay (Joint Weather Station), Prince Patrick Island
Isachsen (Joint Weather Station), Ellef Ringnes Island
Eureka (Joint Weather Station), Ellesmere Island
Alert (Joint Weather Station), Ellesmere Island

NORTHERN GREENLAND

A line of eight stations would be required to provide high and low cover in Northern Greenland. The locations that might be suitable are:

*Cape Morris Jesup	Dronning Louise Land (on rock outcrop)
Nord (Danish Weather Station)	*Peterman's Bjerge (on rock outcrop)
Danmarks Fjord	Cecilea Nunatak (on rock outcrop)
*Moltke's Nunatak (on rock outcrop)	*Gunnbjorns Fjelde (on rock outcrop)

The last named is a proposed site on the Baffin Island – United Kingdom extension of the DEW line. If high cover alone is to be provided, this can be obtained by installing Sentinel radars at the sites starred above (see Fig. 13-4).

Since the plans for Thule defense radar sites were not firm, it did not appear wise to recommend strongly the establishment of this line. The logistics could be handled from Thule by cat train or airlift.

Note that 7 stations, in addition to the Baffin Island – United Kingdom line provide good low cover; 4 or 5 stations could easily provide continuous high cover. The plan should be selected on the basis of the desired protection for Thule AFB.

M.M. Hubbard

APPENDIX 13-E
RADARS AND RADAR STATIONS FOR GENERAL SURVEILLANCE

In the systems of general surveillance and early information lines, it is anticipated that the proposed radars will only infrequently give positive information by reporting aircraft and most of the time will give quite valuable information as a system through the absence of reports. Initially, it might be hoped that little more would be asked of these radars than that they should recognize the presence of an aircraft in a certain region of space. Inevitably, however, more data will be demanded of these radars, first, because it is fairly readily available, and second, because the radars will often have some other use, either primary or secondary, as compared to their general surveillance function. Such increased demands can be easily justified, but will increase the complexity of the radar and hence, perhaps reduce its reliability.

A sort of basic specification for general surveillance radars follows. Increased demands should not be lightly made, nor should gratuitous extras offered by designers be lightly accepted. After setting down basic factors and mixing in what must be variously sized radars, it will be possible to give some examples.

RANGE

Range is a most variable factor because of cross-section variations and the fact that, generally speaking, we can allow large broadside on cross sections in general surveillance, since information on passing flights is of as much value as on approaching flights. However, if we talk of head-on cross sections of about 2 m^2 and ask for free-space ranges on this target, roughly a B-47, we will have safety factors in hand. If we consider that our radar antenna ought to be 15 to 20 feet above the surrounding terrain or the sea, we can say that a 15 nautical mile range will apply to aircraft at altitudes above 70 feet, a 30-mile range to altitudes above 400 feet, a 60-mile range above 2000 feet, and a 100-mile range above 6000 feet. Now, by working backward from the desired low-altitude coverage, one can determine what free-space range is a reasonable demand under the specific circumstances. As an example, if one already has good high cover, there is little advantage in pressing for 60- or 100-mile general-surveillance radars in the same area. On the other hand, at sea in the Atlantic 30- to 60-mile general-surveillance radars are probably the most effective for all altitudes because the shipping density will correspond to distances between ships of over 100 miles, and more platforms to give better low altitude cover are just not available. In the Pacific, so few platforms are available that 60- or even 100-mile radars are a necessity. (See also Appendix 4-C.)

HIGH-ALTITUDE COVER

As is usual, high-angle cover (not quite the same thing as high-altitude cover) will cost range. In areas where general surveillance might act as a gap-filler system below a system of larger radars, it would be well worth considering the limiting of high-altitude cover by providing antennas with higher gain in the vertical plane.

PRECISION

For purely general surveillance, it seems that the range and azimuth accuracies ought to be made good enough so that a track can be determined to, say, ±30°, and the aircraft speed to ±20 per cent. Assuming for the smallest radar that a high-speed aircraft can be watched for 2 minutes, this requirement converts to a range accuracy of ±2 miles and an azimuth accuracy of ±10°. For larger radars the range accuracy can be less, while the azimuth accuracy will probably be better in any event.

DISPLAYS

Again, for purely general surveillance, it does not seem necessary to fit a PPI display. An A-scope ought to be perfectly adequate or, on the smaller sets, range lights and an echo signal strength meter (in order to maximize the echo to determine its bearing). At sea or where a general-surveillance radar serves as a crude control set at bush-type airfields, a PPI might be desirable. Perhaps at sea the PPI of a surface navigation radar could be used.

FREQUENCY

A frequency of less than 1000 or 1500 Mcps should usually be chosen so that an RF amplifier can be used in the receiver, triodes or other negative-grid tubes can be used for transmitting, and relatively large antennas can be used without seriously reducing high-angle cover or producing too narrow a beam in the horizontal plane. Preliminary indications are that frequencies between 200 and 500 Mcps appear most suitable.

TRANSMITTERS

Coherent-pulse systems appear essential and, of these, crystal-controlled power amplifier systems appear most practical. Long pulses and high duty cycles are suitable for these low-precision radars. Final-amplifier power outputs ought to be held up as high as possible until they become a disproportionately

large fraction of the total radar prime power requirement. Self-excited oscillators such as magnetrons should be avoided if at all possible.

RECEIVERS

Vacuum-tube front ends ought to be more useful than crystals in the frequency range concerned. Moving-target indication is probably essential even at sea.

ANTENNAS

For the shorter-range equipments, TV-type antennas such as 5- or 7-element Yagis would be suitable. For larger sets, more conventional dish-type reflectors would be employed.

AUTOMATIC-ALERTING CIRCUITS

Circuits to indicate the presence of moving targets in certain range rings must be provided so that constant human attention is not required. These circuits should be placed at short range to indicate low-altitude targets, at intermediate ranges out to the nominal head-on range of the set, and at one or more greater ranges to react to broadside-on targets. A total of perhaps 6 or 8 such circuits is justified, the number depending on the size of the set. These ought not to be used for range reporting; the A-scope is generally used for this purpose. If no A-scope is fitted in the smallest sets, these alerting gates will have to suffice unless a sliding gate can be readily fitted.

FALSE-ALARM RATES

In distant-information-line radars, false-alarm rates of the order of one per year may be necessary. In general surveillance operation, however, a rate of one per week or per month may be quite acceptable. Low rates are achieved through low sensitivity settings in the automatic-alerting circuits. The loss of sensitivity needs to be carefully balanced against the possible effects of false alarms on the system as influenced by the total number of valid reports, and on the individual radars as influenced by the number of aircraft seen by each and the degree of irritation caused to volunteer personnel by false alarms at off-duty hours.

POSSIBLE EXAMPLES

<u>10 – 15 mile</u>:– A revised version of the Chipmunk radar, still about the size of a table model TV but employing somewhat more transmitter power and a larger Yagi antenna.

20 – 30 mile:– The Super Chipmunk or Chipmunk II as described elsewhere in the Lamp Light report. This radar lies at the crossover between Yagis and dish reflectors and might be allowed to have a higher false-alarm rate and hence more sensitivity than described elsewhere. (See Appendix 4-D.)

60 – 100 mile:– This larger radar needs development from the Sentinel proposed by Lincoln Laboratory as a replacement for the X-3 DEW line radar. The Sentinel with 250- to 300-mile free-space range on a B-47 has too large an antenna for indiscriminate shipboard fitting and probably for many land-based stations. In this development, a reasonable antenna size could be selected by consultation with naval and maritime administration authorities, bearing in mind the application to the Pacific. Having fixed the antenna size, the set may then be designed. It may be necessary to accept a higher false-alarm rate in this set than in the smaller sets, in view of the lower ship density in the Pacific.

RADAR STATIONS AT SEA

It is apparent that ships should be enrolled in various categories, depending on such factors as normal routes, flags, degree to which Naval Reserve personnel are employed, size, speed, communications facilities available, and the case of organization which in turn depends on whether or not a ship is a member of a fleet. For general surveillance in the Atlantic, a 20- or 30-mile radar ought to be fitted. In the Pacific a larger set is probably necessary. For special duties, such as low-altitude cover off the Newfoundland-Nova Scotia-New England area, a 10 to 15 mile set is not unreasonably large for fishing vessels. At sea, the manpower situation may be regarded as simple, since deck officers on duty will normally be able to respond to automatic-alerting calls and to examine the display indications.

RADAR STATIONS ON LAND

In attempting to set up a system of general surveillance in an area such as Northern Canada, two factors are of prime importance – manpower and special purposes. Since stations will be fixed and of various classes, each possible location will require individual consideration. Examination of possible locations will reveal that it is necessary to consider general surveillance in most of this area on a line-type basis rather than an area basis and hence that large gaps should not be left along an irregular line running generally east and west half way between the Mid-Canada and the DEW lines. In the area nearer the Mid-Canada line and along the Alcan Highway and the MacKenzie River, other systems, part line-type and part area-type, can be visualized.

As a first step, the general method of establishing these lines is to take advantage of such locations as are available where radars can be placed without any extra men. Secondly, locations where one or two extra men will be needed can be chosen. Thirdly, complete stations can be established when necessary to fill gaps. In such a program the low-altitude limit must be kept in mind as well as any programed high-altitude cover. The possibility of truly unmanned stations for very-low-altitude gap filling between general surveillance stations also needs consideration.

As a first stage, all military airfields should be required to establish large radars of the 60- to 100-mile class which can also be used for control of aircraft. All commercial airfields should be requested to operate radars of a similar type; such radars could be supplied by the military. Department of Transport airfields would be requested or required to do the same. At other military posts or DOT weather stations, similar or slightly smaller radars could be added; these generally fall into the class of stations where extra manpower may be needed – possibly not Air Force personnel. In this area, say from 60° to 65° N, it does not seem reasonable to depend on Hudson Bay factors or missionaries to handle the larger radars, while the density of such posts is too low to make the use of smaller radars profitable. They would, however, be useful against a widespread, non-ferret, type of raid. Again, an on-the-spot investigation of the capabilities and requirements is needed for each station.

Farther south, near the Mid-Canada line, a Ground Observer Corps organization becomes practical in Western Canada and here the 10- to 15-mile radar or the 20- to 30-mile becomes highly useful. Here the principle is not so much to attempt a minor northward extension of warning but to provide a means of controlling and identifying itinerant bush flyers. Except for exploratory and fishing trips, these flights go to settlements and at each of these terminals a small radar would help greatly for control, identification, and search and rescue purposes.

Based on these principles, a rough system has been examined which would give at least one report on an aircraft flying above 2000 feet between the DEW and the Mid-Canada lines. This system is shown in Fig. 13E-1 as a total of 32 stations with radars capable of 75-mile range. These stations are listed below and are of all categories from well established cities (Churchill, Yellowknife and Whitehorse) through about 20 airfield locations, to about half-a-dozen places requiring more extensive manning and the establishment or re-establishment of presently unoccupied posts. These last are those places where 8 to 12 men might be required in the absence of rigorous low manning procedures. Additionally, some 20 small stations are shown near the Mid-Canada

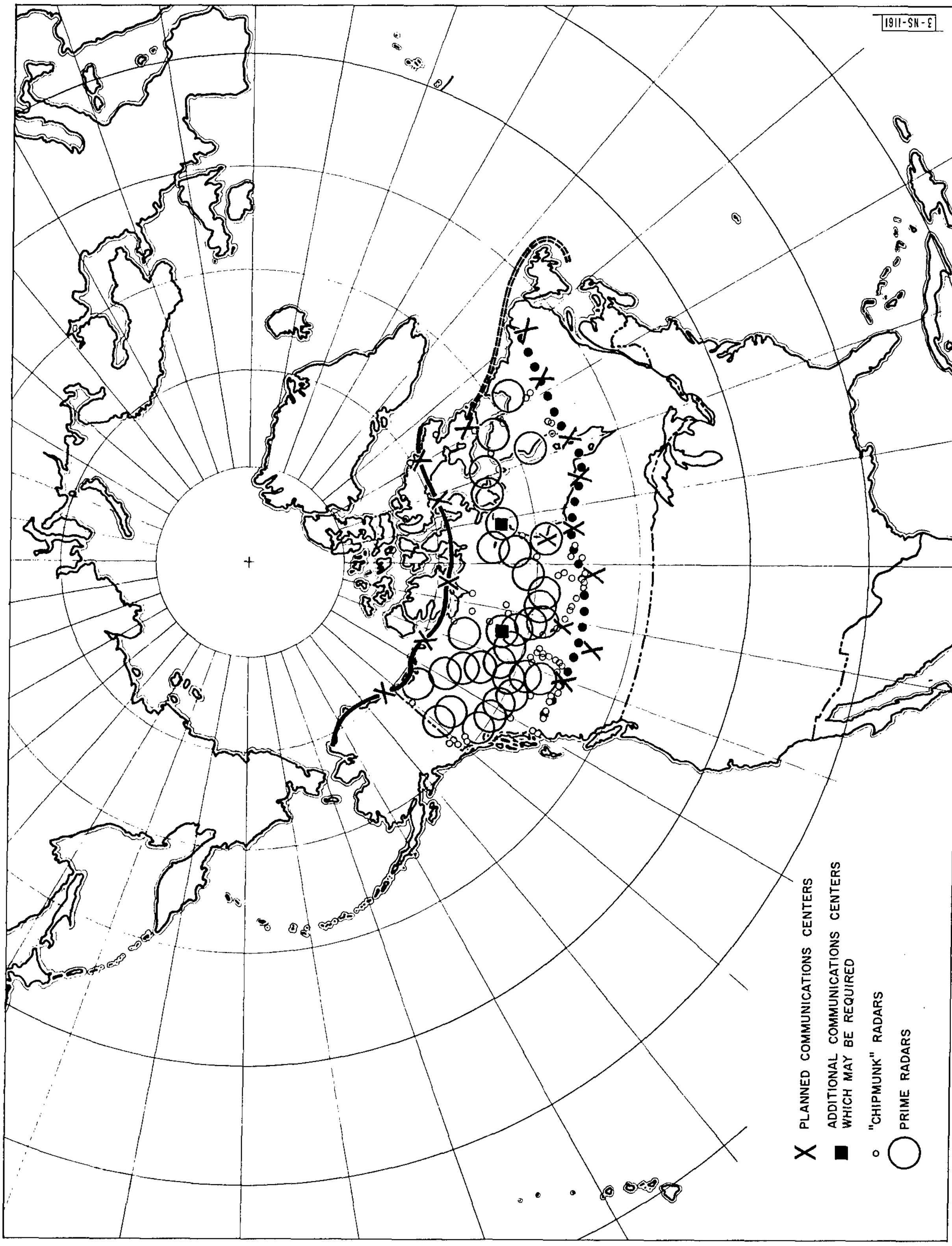

Fig. 13E-1. General surveillance in Northern Canada.

line and 45 are tentatively positioned elsewhere, including a few north of the DEW line. As explained in the body of the report, the total capital cost for radars, extra construction, extra communications facilities and power ought to be less than $10,000,000.

LARGE RADAR SITES

Aklavik	Dawson	Churchill
Port Radium	Mayo	Ennadei Lake
Fort Good Hope	Whitehorse	Baker Lake
Norman Wells	Teslin	Padlei
Wrigley	Watson Lake	Chesterfield Inlet
Fort Simpson	Smith River	Coral Harbour
Fort Providence	Fort Nelson	Nottingham Island
Fort Resolution	Beaton River	Port Harrison
Fort Smith	Fort Liard	Wakeham Bay
Yellowknife	Goldfields	Fort Chimo
Enbarrass	Stormy Rapids	

R.S. Rettie

APPENDIX 13-F

DETECTION CAPABILITIES OF OCEAN SHIPPING

METHOD OF STUDY

In order to determine the expected number of reports from shipping randomly scattered near the path of an aircraft, the following procedure was adopted. Flight paths of interest were selected and, using transparent plastics, were overlaid on charts of shipping positions as swaths twice as wide as the assumed radar range considered. In order to take account of day-to-day variations of shipping positions, several parallel swaths, or one several times as wide, were used. All ships lying inside the boundaries of the swaths were counted and totaled over various lengths of the flight path. The total so obtained was divided by the number of swaths employed or by the appropriate factor for the wider swath to get the expected number of reports along the path. It became obvious very shortly that the theoretical prediction, outlined in Appendix 4-C of the Lamp Light report, that the number of sightings on a given flight should be proportional to the radar range employed, was borne out even in the low-density traffic in the Pacific. Hence the quicker process of using one wide swath was used in most of the counting work.

The Atlantic

In the Atlantic, one path only seemed necessary due to the high and relatively constant shipping density. This path ran from a point south of Greenland on the 50th parallel toward Cape May but curved well away from Newfoundland and Nova Scotia. The ships in a 200-mile swath were counted, a cumulative total being kept and adjusted for a radar range of 30 miles (also 10). Thus it was shown that with 30-mile radars, the expected number of sightings would be 3 per 250 miles in the early portions of the route with a much higher number nearer the coast. These figures were converted to the curves of Fig. 13-8 in Chapter 13, giving the cumulative probability of 3 or more reports along the path for various radar ranges and fractions of ships fitted. It should be noted that the starting point of these curves can be any distance along the path so that if we have had a few reports between, say, 1400 and 1800 miles from Cape May, then the cumulative probability of 3 or more reports inside of 1400 miles is given again by the curve valid for starting 1800 miles away, and we would have a very high probability of 3 or more reports in the next 400 miles.

The Pacific

Due to the lower density of shipping, a more extensive study of various flight paths of interest were chosen. The first set of 12 were 6 each from Petropavlovsk and Sakhalin,

running in each case to 6 randomly chosen latitudes on the 180° meridian, below the Aleutians and with the most southerly going south of Midway. The first 1500 miles of each path were examined for shipping distributions of May 1952 and November 1954, and the counts resulting are given in Table 13F-I. On the whole, the results are

TABLE 13F-1

COUNT OF PACIFIC SHIPPING

Path	6 x 60 Mile Lanes 1952	3 x 120 Mile Lanes 1952	1 x180 Mile Lane 1954	1 x 360 Mile Lane 1954
P1	(1,1,2,1,3,3) – 11	(5,3,5) – 13	6	11
P2	(3,2,1,0,1,1) – 8	(5,2,5) – 12	7	12
P3	(1,2,4,3,5,5) – 20	(1,5,5) – 11	6	15
P4	(0,0,0,0,1,1) – 2	(2,0,9) – 11	6	13
P5	(4,4,2,2,1,0) – 13	(10,4,0) – 14	6	10
P6	(4,4,4,5,4,3) – 24	(9,7,2) – 18	3	8
S1	(2,2,0,0,0,0) – 4	(2,2,0) – 4	3	11
S2	(2,0,0,2,2,0) – 6	(3,2,0) – 5	7	13
S3	(1,2,4,3,2,2) – 14	(7,5,2) – 14	7	14
S4	(3,4,3,2,2,2) – 16	(5,6,6) – 17	4	11
S5	(2,1,0,0,2,3) – 8	(4,2,5) – 11	5	9
S6	(2,3,4,5,3,3) – 20	(5,8,6) – 19	9	16
	TOTAL 146	149	69	143
	Expected Radar Sightings*			
	30-Mile Radar 2	60-Mile Radar 4	30-Mile Radar 2	60-Mile Radar 4

*Expected sightings were obtained by dividing total ship count in each column by total effective number of lanes in each column. It will be noted that the effective number of lanes is a function of the range of the radar selected.

extraordinarily consistent, particularly in the totals before dividing by 6 times the effective number of lanes to get the expected sightings. The individual lane counts have not been examined closely, but the variations are about as expected for such low numbers. A few peculiarities, such as the cases for May 1952 on paths P3 and P4, are attributable to minor inaccuracies in the multiple lane overlay, some extremely closely bunched groups of ships, and a deliberate attempt to match the ends of the overlays properly. Thus the 30-mile radar appears better than the 60-mile in path P3 and

TABLE 13F – II								
EXPECTED NUMBER OF SIGHTINGS OF TRANS-PACIFIC FLIGHTS								
	West of 180°		180° to 150° W		150° W-100 Miles from Coast		TOTALS	
Radar	30 mile	60 mile	30 mile	60 mile	30 mile	60 mile	30 mile	60 mile
P1	0.5(1.3)	0.7(2.7)	2.3(2.7)	4.7(5.3)	1.7(0.7)	3.7(2)	4.5(4.7)	9(10)
P2	0.5(1.3)	0.7(2.7)	3(0.3)	5.7(1.3)	4(1)	4.3(2.7)	7.5(2.7)	10.7(6.7)
P3	2.7(2.3)	4.7(3.7)	0.7(0.3)	2.7(1)	3.2(1.7)	6.3(2.7)	6.5(4.3)	13.7(7.3)
P41	1.5(2.7)	5.3(4.7)	?(0.3)	?(1.3)	2.3(0)	4(2.3)	3.8(3)	9.3(8.3)
P42	1.5(2.7)	5.3(4.7)	?(0.3)	?(1.3)	2.8(2.7)	4(3)	4.3(5.7)	9.3(9)
P43	1.5(2.7)	5.3(4.7)	?(0.3)	?(1.3)	0.7(2.7)	2.3(3.7)	2.2(5.7)	7.7(9.7)
P44	1.5(2.7)	5.3(4.7)	?(0.3)	?(1.3)	0.5(1.3)	0.7(3.7)	2.(4.3)	6(9.7)
S1	0.7(2)	1.3(4.7)	2.3(2.7)	4.7(5.3)	1.7(0.7)	3.7(2)	4.7(5.3)	9.7(12)
S2	1.2(2)	3.3(4.7)	2.5(0.3)	6(0.7)	4(1)	4.3(2.7)	7.7(3.3)	13.7(8)
S3	3.3(2)	6.7(4)	0.7(0.3)	2.7(1)	3.2(1.7)	6.3(2.7)	7.2(4)	15.7(7.7)
S41	1.8(2.3)	7.7(5)	?(0.3)	?(1.3)	2.3(0)	4(2.3)	4.2(2.7)	11.7(8.7)
S42	1.8(2.3)	7.7(5)	?(0.3)	?(1.3)	2.8(2.7)	4(3)	4.7(5.3)	11.7(9.3)
S43	1.8(2.3)	7.7(5)	?(0.3)	?(1.3)	0.7(2.7)	2.3(3.7)	2.5(5.3)	10(10)
S44	1.8(2.3)	7.7(5)	?(0.3)	?(1.3)	0.5(1.3)	0.7(3.7)	2.3(4)	8.3(10)

relatively very much worse in P4. The numbers in columns 1 and 2 should by theory be equal, while column 4 should be twice column 3. P refers to paths from Petropavlovsk, S to paths from Sakhalin.

Table 13F-I shows that we should expect 2 reports from 30-mile radars for any of these paths and 4 from 60-mile sets. With such a low expected value as 2, probability of getting no reports at all is 13 per cent, that of getting at least one, 87 per cent. The advantage of 60-mile radars at least for higher altitudes is obvious since, for an expected value of 4, the probability of at least one report is 98 per cent, and of at least 3 is 76 per cent.

A second series of flight paths were also checked, starting again from Petropavlovsk and Sakhalin, proceeding to convenient, blindly chosen, meeting and turning points on the 180° or 170° meridian, and thence more or less straight to Seattle, San Francisco and Los Angeles. The most southerly route again went south of Midway and Hawaii and then northeast to Seattle, San Francisco, Los Angeles and San Diego as four branch routes. Numbering the U.S. cities from north to south, these routes can be labeled P1, P2, P3, P41, P42, P43, P44 and S1, S2, S3, S41, S42, S43, S44, and for the purpose of this study need not be specified further in most cases. Along certain portions of these routes, two or more routes coincide. Routes such as P41 lie south of Midway and Hawaii and data were not readily available in 1952 for the portion between 180° and 150°W. The numbers in brackets refer to 1954, the others to 1952.

The numbers in Table 13F-II may be rounded off or converted to cumulative probabilities for at least 3, 5 or 10 sightings as desired. The most likely areas for these sightings can be guessed by inspection and it appears that the mid-Pacific is the poorest area because flight paths and shipping lanes are roughly parallel. Under such conditions, we might expect either a very large number of sightings or a very small number.

The averages over all these routes may be somewhat misleading because of the use of common sections on various routes. However, for 30-mile radars, one would have expected 4.6 reports in 1952 and 4.3 in 1954, and for 60-mile radars, 10.5 and 9.0, respectively. The 30-mile figures might well represent low-altitude figures above about 400 feet and the 60-mile figures for flights above about 2000 feet.

R.S. Rettie

APPENDIX 13-G
THE IMMEDIATE IMPLEMENTATION OF GENERAL SURVEILLANCE AT SEA

As an immediate start toward a general surveillance system at sea, the U.S. Merchant Marine Fleet provides an excellent base, with or without air-search radar. Perhaps the most important feature of an immediate start would be the experience gained with the communications system. Among the special advantages of the U.S. Merchant Marine Fleet are:

> A large number of vessels are Government subsidized, and therefore a large proportion of the officers is required to belong to the Naval Reserve.
>
> Most of the ships are large and modern and have cruising speeds above 14 knots, and most of them were built during or after World War II.
>
> The pattern of shipping in the Atlantic is such that if radars of approximately 75-mile range were installed, the area south of 50°N would be well covered.
>
> Practically all the Active Fleet is suitable for installation of air-search radar the size of the TPS-1D or SRa.
>
> Most ships are equipped with surface-search radars, and hence the officer personnel is familiar with plotting procedures.

Vessel Inventory Report (Report No. 140) of Ship Data Branch, Maritime Administration, lists the U.S. Flag Dry Cargo and Tanker Fleets of 1,000 gross tons and over as follows:

> Active Fleet:– 1327 vessels
>
> Reserve Fleet:– 2034 vessels

SECURITY OF MERCHANT VESSELS

The security of U.S. Merchant Marine personnel has been greatly improved as a result of laws enacted since World War II.

Public Law 679, 81st Congress, 2nd Session, approved 9 August 1950, gives the U.S. Coast Guard the responsibility for the security of officer and certificated personnel. Unless such personnel have a clearance from the Coast Guard, they may not "sign on" for a voyage. In general, this requirement applies to all vessels of 100 gross tons or upward.

Details are included in a U.S. Coast Guard publication "Security of Vessels and Waterfront Facilities," dated 16 June 1952.

A POSSIBLE INTERIM RADAR SET FOR MERCHANT VESSELS

In order to gain experience and some reporting potential from general surveillance before specially designed radars are available, it would be worth while to modify some AN/TPS-1D radars for shipboard fitting. Since it is hoped that air-search radars can be added without extra crew for operation or maintenance, it is proposed that installation and maintenance of the equipment be on a contract basis with a commercial company. Informal discussion with representatives of Raytheon indicates that they consider the maintenance of the TPS-1D radar on a voyage-end basis to be feasible.

The main modifications considered to render the TPS-1D suitable for the shipboard use are:

Addition of the automatic-alarm feature developed by Lincoln Laboratory.

Deletion of the moving-target indication feature (not required for the ship application, and a source of maintenance difficulty).

Employment of a high-altitude antenna (csc^2) to improve present coverage.

The installation suggested is placement of the equipment on the bridge level with the indicator in the bridge or chart house and the antenna mounted on top of the chart house rather than high on a mast.

Raytheon estimates for modification and installation are less than $30,000. Based on experience with maintaining their Pathfinder surface-search radar, Raytheon estimates that annual maintenance would amount to approximately $1,000 per year for replacement parts, plus $1,200 for labor – a total of $2,700 per year per ship.

LOW-ALTITUDE COVER FROM FISHING VESSELS

Before the plans for picket vessels and AEW are implemented, a useful form of low-altitude cover can be obtained from East Coast Canadian and U. S. fishing vessels operating from Georges Bank to the Grand Banks.

Table 13G-I shows the home ports of vessels of more than 40 tons operating in this area.

Of these vessels, two-thirds are normally at sea, nearly all have voice communications, half of the U. S. and one-fifth of the Canadian ships have navigational radar.

TABLE 13 G-I

Vessels Exceeding 40 Tons Based on Northeast Coast

Home Port	Number
Boston	60
New Bedford	100
Gloucester	100
Portland	35
Rockland	30
Nova Scotia	100
Newfoundland	40
	465

Further details are available in the following publications:

Development of a World-Wide Air Surveillance System, Project 21 of the Joint Air Defense Board.

Aircraft Reporting Potential of Canadian Fishing Vessels; ORG Memo No. 49, Defence Research Board, Canada.

J.H. Griffin

APPENDIX 13-H
AIR TRAFFIC IN OCEAN AREAS

Friendly air traffic in ocean areas is of interest because of the necessity of identifying all such flights and allowing their entry into the continental air defense system. Friendly air traffic also may assist the defense system in many ways, particularly if equipped with navigational or search radars. Possible contributions are as low-caliber AEW aircraft supplementing military AEW or the general surveillance system, as radar "flooders" to help in the process of keeping submarines submerged, and as sources of data for sea traffic control.

ATLANTIC DISTRIBUTION—COMMERCIAL

Total Number of Flights

In December 1954 there were 296 scheduled crossings both ways per week by all commercial airlines, or an average of 42 per day. About 46 per cent of the crossings are made by the two American lines – PAA and TWA. In the summer the number of flights increases somewhat. For example, TWA crossings increase from 64 per week in winter to 88 per week in summer. The number of actual crossings closely approximates the scheduled crossings, since extra sections and canceled flights nearly balance each other. Most of the information contained herein was obtained from the navigation sections of TWA and PAA and the operations analysis section of PAA.

Flight Paths

The flight paths depend primarily on the scheduled stops and the weather. Great effort is made to take advantage of favorable winds. The flight paths are very seldom Great Circle routes. A given flight may go by way of the Azores one day, and by Keflavik the next.

PAA has made an intensive study of the so-called least-time track. Taking the weather into account, a graphical construction method is used to find the track between two given points, which represents the least travel time and hence the least fuel consumption. The other airlines also attempt to minimize the flight time. There are a number of possible routes. Flights originate at New York, Boston, Montreal, London, Prestwick, Paris, Lisbon and Copenhagen. Stops may be made at Keflavik, Shannon, Gander, Goose Bay, BW8 and the Azores.

Figures 13H-1(a) and 13H-1(b) show some calculated least-time tracks eastbound at 18,000 feet for 6 recent months. At the present time, PAA is making many of its eastbound flights nonstop Idlewild to London so that the least-time tracks are actually

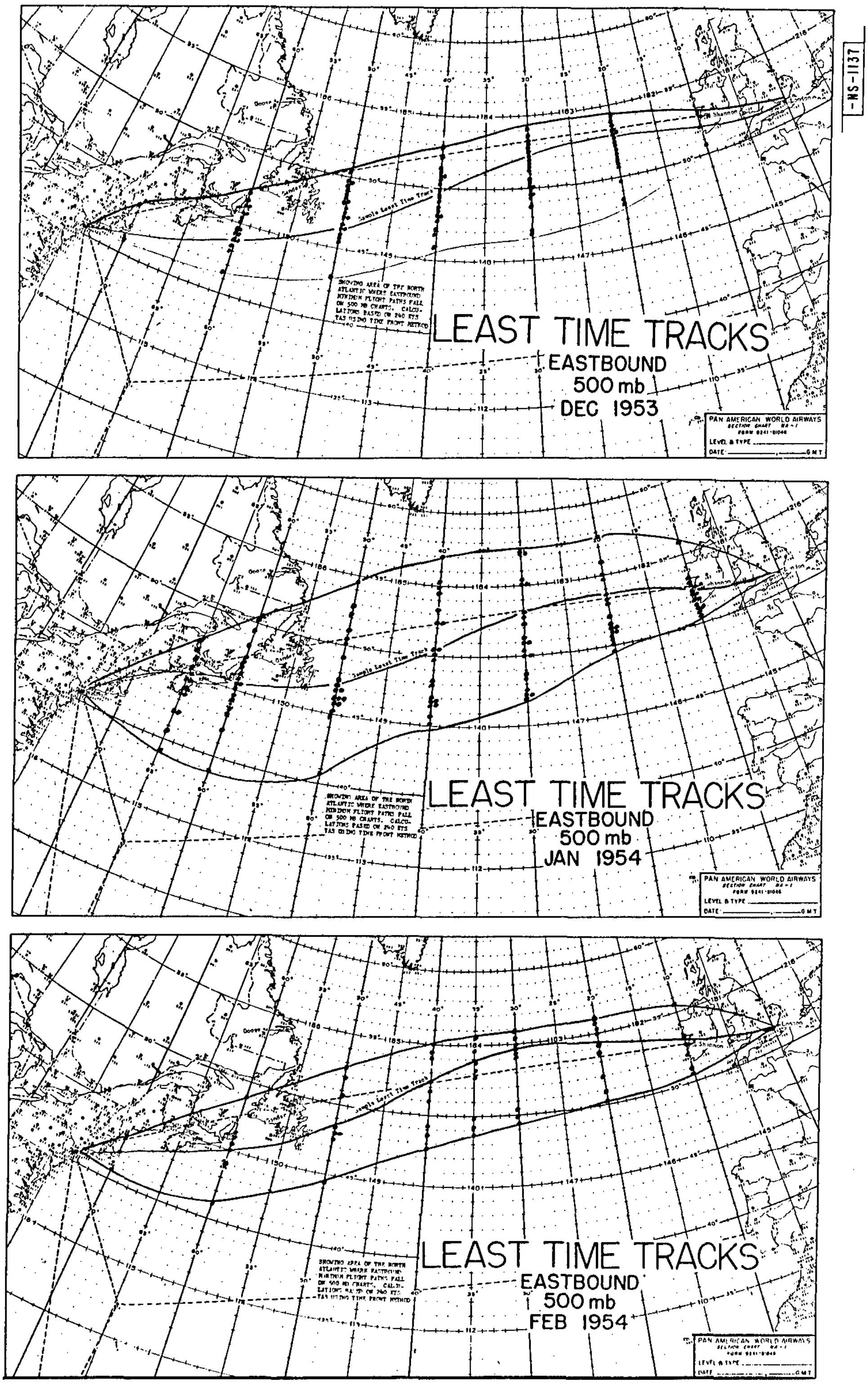

Fig. 13H-1(a). Least-time tracks eastbound (December 1953, January and February 1954).

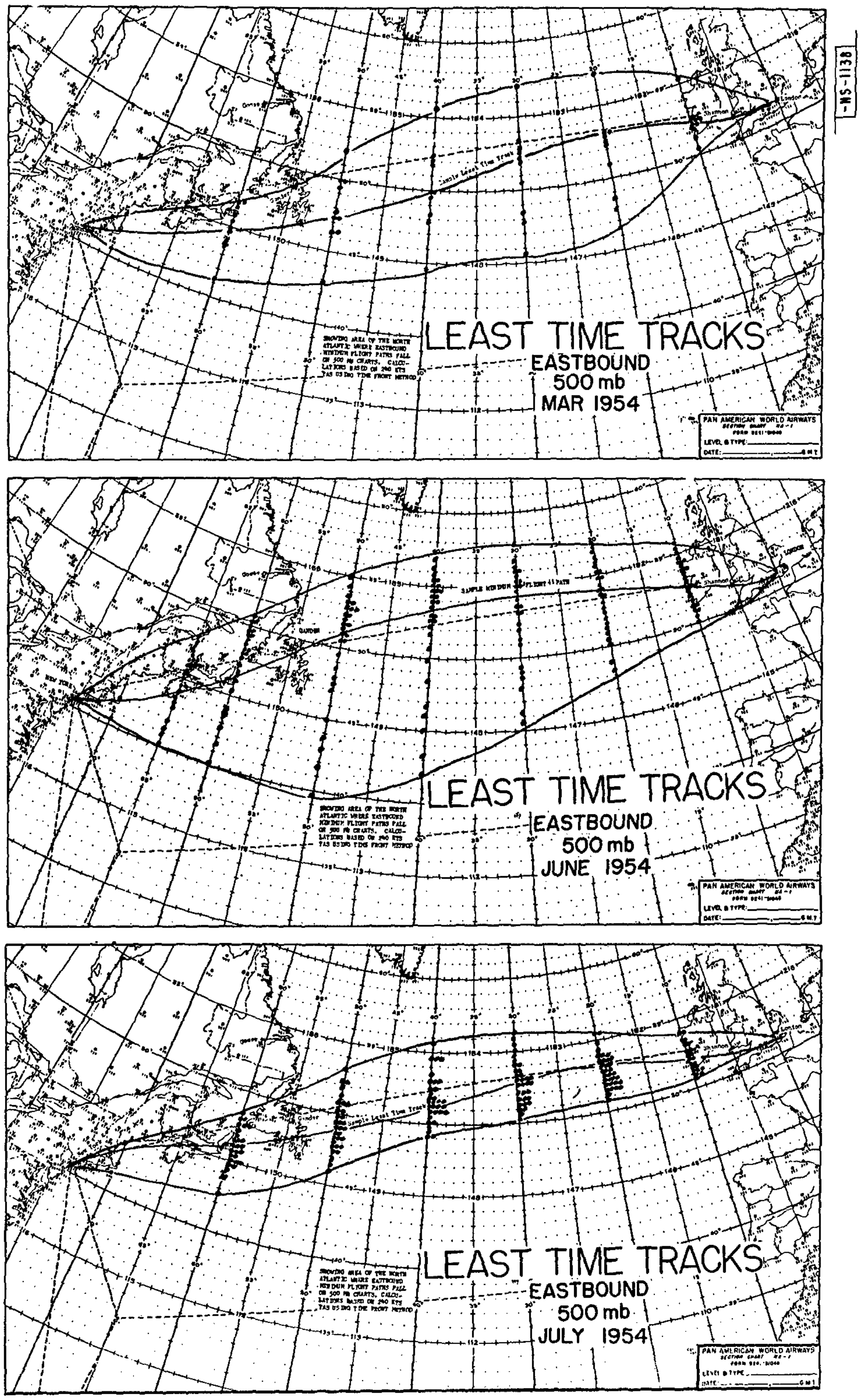

Fig. 13H-1(b). Least-time tracks eastbound (March, June and July 1954).

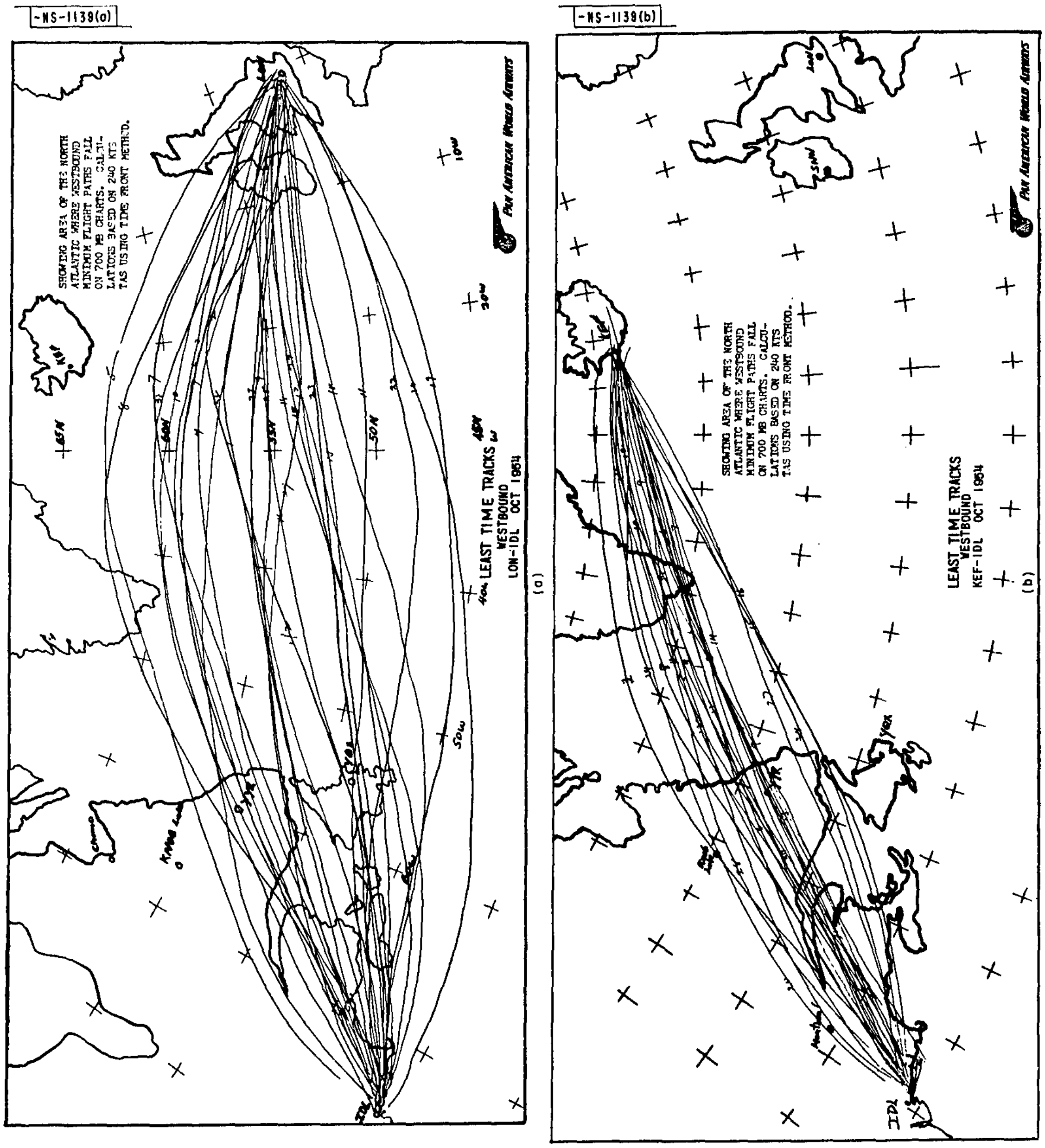

Fig. 13H-2. Least-time tracks westbound.

flown by a large number of flights. Figure 13H-2 shows some calculated least-time tracks westbound at a lower altitude. Nonstop London to Idlewild flights are relatively rare. A large number of westbound flights, especially in winter, is routed via Keflavik. Figures 13H-3, 13H-4, 13H-5 and 13H-6 show the courses taken by TWA flights on 4 randomly chosen days in the Fall of 1954. Figure 13H-8 shows Pan-American flights over a period of 2-1/2 weeks in November 1954. These tracks were obtained from the navigator's plot. It is evident that the flights are well spread out over a large area of the ocean.

Communications and Navigation

In ocean areas all planes are required to report to the appropriate oceanic control station each hour, giving their present position and their expected position for the next hour. Over the ocean the planes know their position to a precision of about 20 miles.

ATLANTIC DISTRIBUTION – TOTAL

The addition of military flights brings the total number of flights up to about 80 per day, of which 60 are north of 50°. The southern route via the Azores has relatively fewer commercial flights than the northern routes. The day-to-day spread of least-time tracks on typical northern route (New York to London) is at least 300 miles north of the Great Circle route and 600 miles south. The number of aircraft (60) crossing on northern routes both ways is such that, on the average, one might expect to find one aircraft per 2.5° of longitude.

ATLANTIC DISTRIBUTION – SPECIAL FEATURES

Westbound

Least-time tracks tend to concentrate near the southern tip of Greenland and would be subject to observation from radars at Simiutak (BWI) and Prince Christian. Little of this traffic crosses the fishing grounds between Georges Bank and Grand Banks, and practically none crosses the Argentia-Azores line. Southern routes generally lie south of the Argentia-Azores line.

Eastbound

About 25 per cent of the northern route flights cross the Argentia-Azores line.

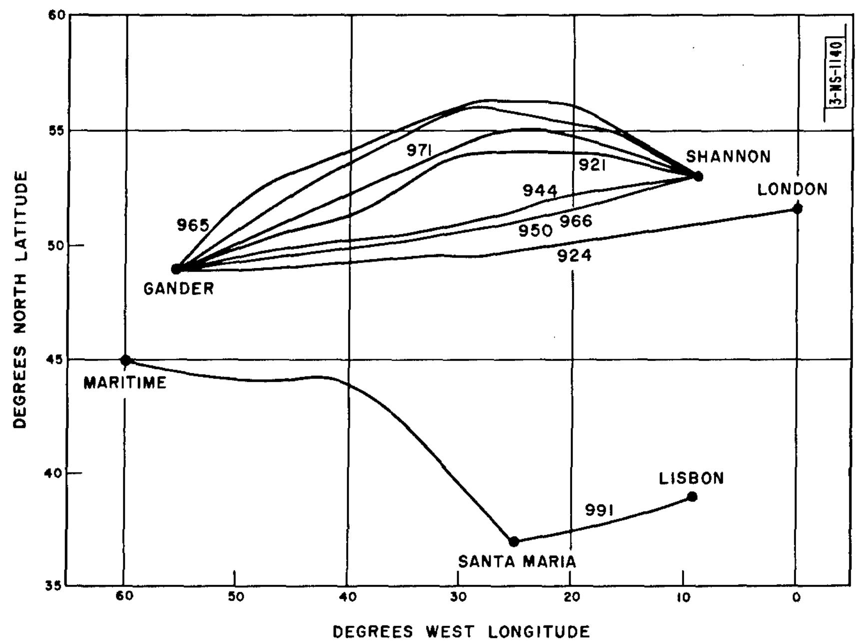

Fig. 13H-3. TWA flight paths (16 October 1954).

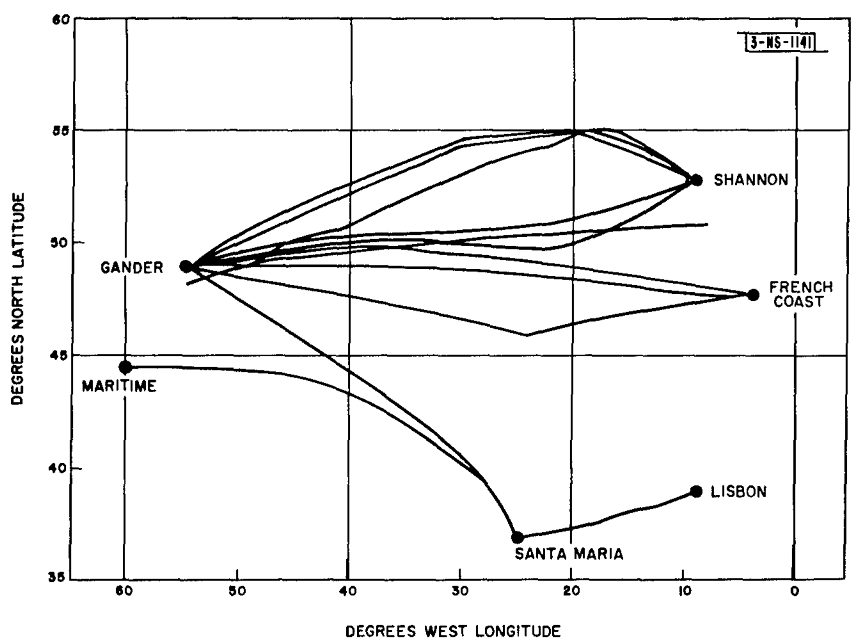

Fig. 13H-4. TWA flight paths (17 October 1954).

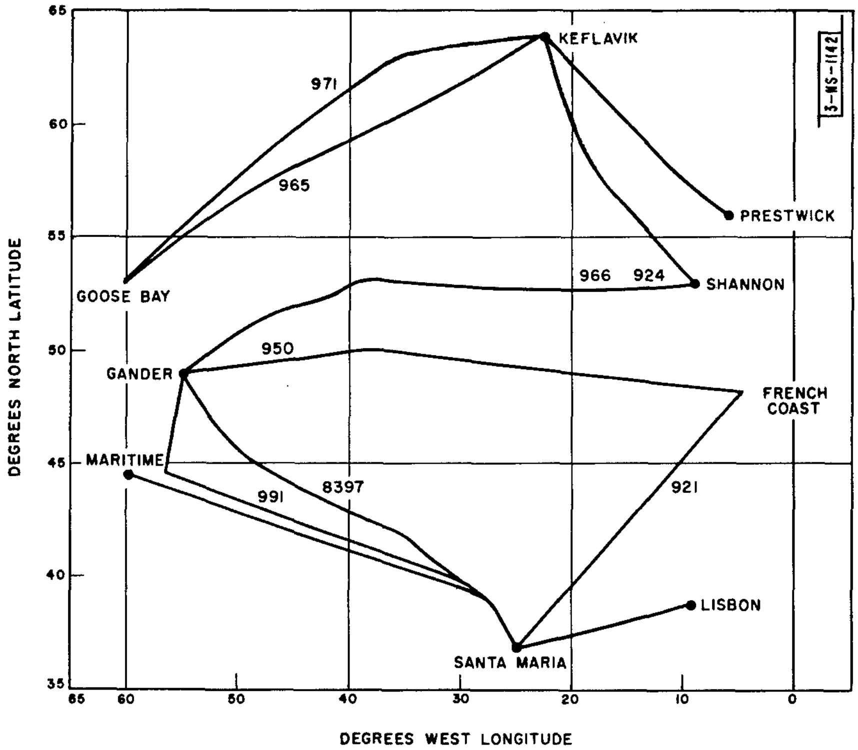

Fig. 13H-5. TWA flight paths (30 October 1954).

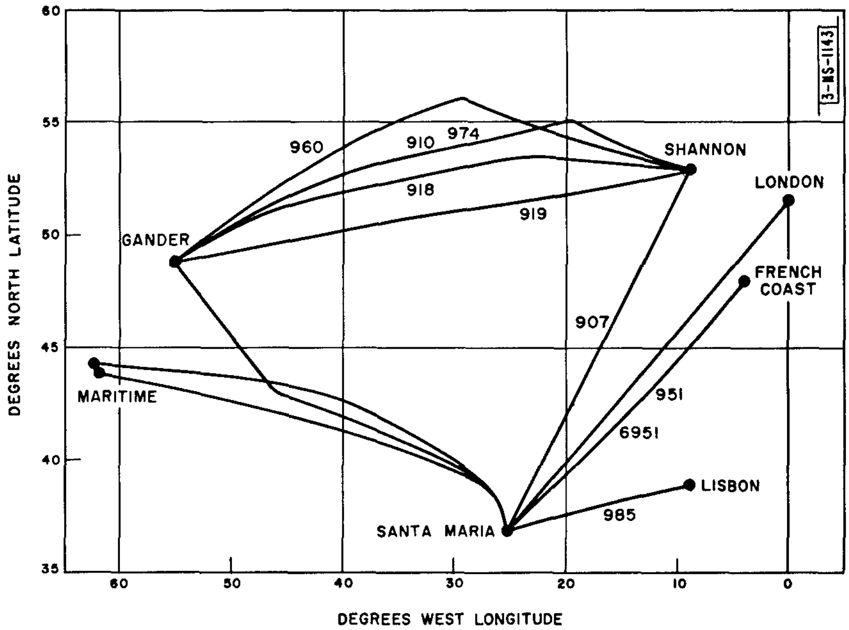

Fig. 13H-6. TWA flight paths (20 December 1954).

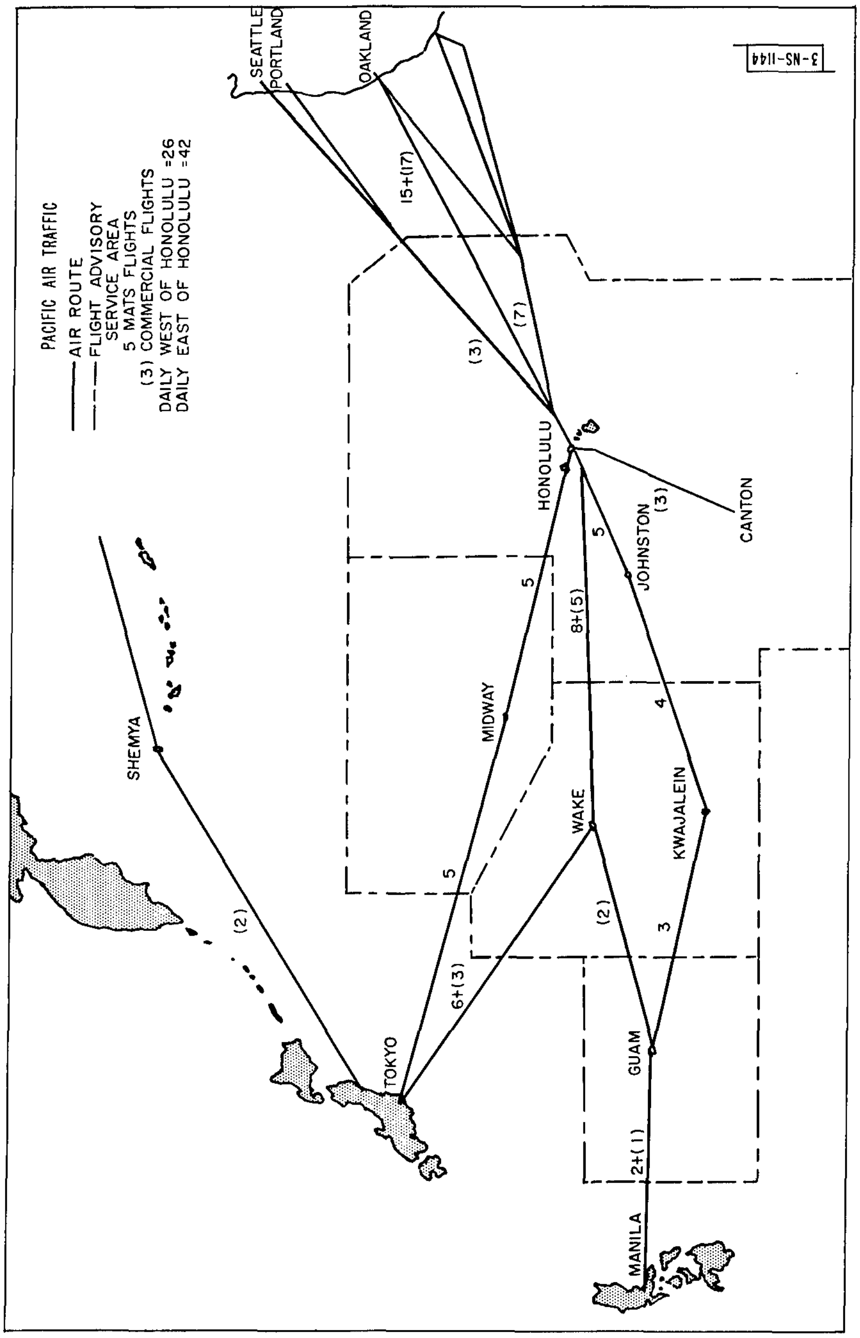

Fig. 13H-7. Pacific air traffic.

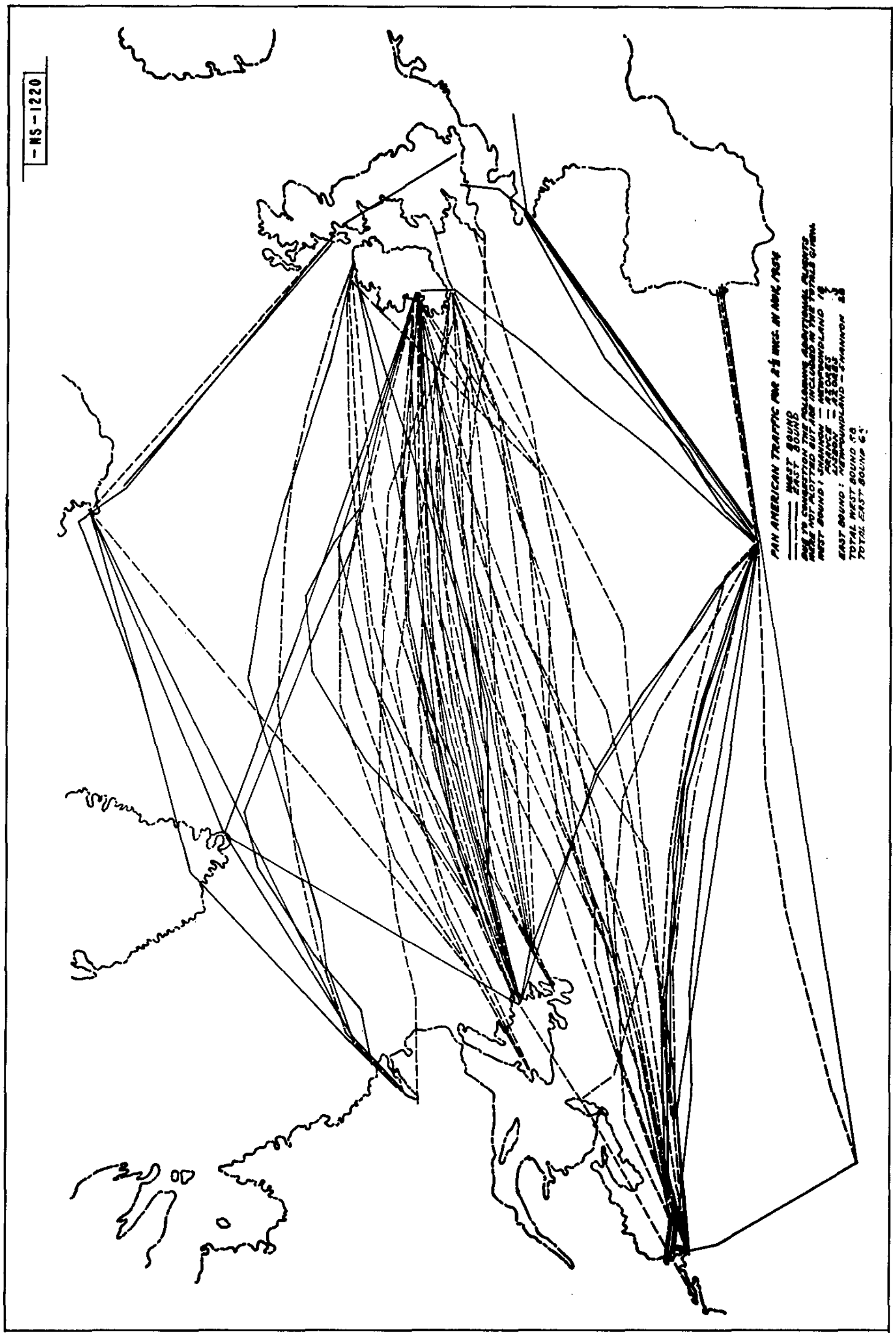

Fig. 13H-8. Pan-American flights over a period of 2-1/2 weeks in November 1954.

PACIFIC DISTRIBUTION

In the Pacific the pattern of air routes is not so widespread in mid-ocean as in the Atlantic, because most of it channels through Oahu in the Hawaiian Islands. Figure 13H-7 shows the main routes flown and indicates the amount of traffic.

POSSIBLE USE IN SEA TRAFFIC CONTROL

Most military trans-oceanic aircraft are now equipped with a search radar and commercial companies are planning to install radars for weather and navigational use.

The following conclusions were drawn from an investigation of the feasibility of using presently installed radars for contributing to surface surveillance.

> The APS-42 radar installed in military transport aircraft gives average detection ranges of 50 miles on ships.
>
> Availability of an automatic-alarm feature such as that under development by the Lincoln Laboratory would facilitate and improve the efficiency of search. Without the automatic-alarm feature, flight crews probably would have to be augmented to insure obtaining an important amount of data.

As previously stated, many trans-oceanic flights regularly carry navigational radars. These possess some short-range air surveillance potential. It would be profitable to investigate the feasibility, range penalties, costs and possible radar performance of radar "pods" to be attached as complete appliques to transport or commercial airplanes. Performance degraded from that expected of standard AEW patrols would still be valuable to fill in the surveillance north of the shipping lanes.

J.H. Griffin

APPENDIX 13-I

OPERATIONAL PROBABILITIES AND AVAILABILITY

KILL POTENTIAL

Table 13I-I lists a set of figures for various probabilities of the interceptor operation. An attempt has been made to use estimated figures compatible with those for other weapon systems of an over-all defense system. Using the figures of this table, we find:

$$K = 2.9 \quad .$$

This kill potential figure was used in the cost-effectiveness estimate of Chapter 15.

AVAILABILITY

Table 13I-II lists an availability schedule for a squadron of 15 RAB interceptors. Again, these figures were chosen to be compatible with those of the Basic Lamp Light System.

TABLE 13I-I

RAB INTERCEPTOR OPERATIONAL PROBABILITIES

P_a = probability of reaching target area (includes aborts and gross errors)	0.8
P_c = probability of detection and conversion to attack having reached the target area	0.8
P_k = missile single-shot kill probability	0.8
P_r = probability of converting to a second attack, having made an attack	0.9

The kill potential of an interceptor carrying N missiles is defined by:

$$K = P_a P_c P_k \sum_{i=0}^{N-1} P_r^i = P_a P_c P_k \frac{1 - P_r^N}{1 - P_r}$$

TABLE 13I-II

AVAILABILITY OF A SQUADRON RAB INTERCEPTORS

Maintenance	5
Combat-Ready	10
In 15 minutes	2
In 30 minutes	2
In 60 minutes	2
In 90 minutes	2
In 120 minutes	2

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A. Stieber
C.M. Forsyth

APPENDIX 13-J
COST EFFECTIVENESS ESTIMATE

REMOTE-AIR-BATTLE COST ESTIMATES

Cost estimates contained herein were arrived at by use of ADC estimates, USAF Management Analysis Service and, in part, by Lamp Light estimates. In general, the costs given are 20 to 35 per cent larger than published estimates relating to some items. Since this is due largely to operations outside of continental United States, it is felt that the costs listed in Tables 13J-I, 13J-II and 13J-III are a generous upper bound. (These cost estimates were used in the cost-effectiveness evaluations of Chap. 15.)

TABLE 13J-I

CAPITAL COSTS

Interceptor	Cost (in millions)
Initial aircraft cost for 1 wing (45 B-47E's)	$110
Spare parts, stocks and supplies	40
Organizational equipment ($4,000 per military man)	12
Personnel training	15
Initial transportation	2
Missiles (15 missiles per aircraft at approximately $50,000 per missile)	34
Miscellaneous	2
TOTAL	215
AEW Aircraft	
1 wing (45 aircraft)	191
Arctic Ground-Based Barrier	
8 stations ($5 million each)	40
Base Costs	
New (below 60°N)	50
Improvement of existing facility (average)	10

TABLE 13J-II	
ANNUAL OPERATING COST	
	Cost (in millions)
Interceptor (1 wing, 45 aircraft) (SAC wing, approximately 65 million)	
Base level operating cost (payroll, aircraft fuel, maintenance supplies, contractual and miscellaneous costs)	$28
Off-base support cost (replacement of aircraft, personnel depot maintenance, supply division costs)	47
TOTAL	75
AEW	51
Arctic Ground-Based Barrier	8

EFFECTIVENESS

Since intercept of the "typical" strike (as described in Chap. 13) occurs over a long time period and – against the large-scale strikes assumed RAB-raid attrition is below 50 per cent, it is reasonable to estimate the number of bombers killed by multiplying the number of interceptors committed by the kill potential of each interceptor. Here, then, it is unnecessary to introduce the more sophisticated methods of estimating kills by considering degradations due to time-to-die and random missile-to-target assignment. It may also be shown that, for less than 50 per cent attrition in the outer defenses, it is not profitable for the enemy to decoy the outer defenses at the expense of decoying the inner defense.

Using the number of interceptors in action (as given in Chap. 13), the kill potential (determined from App. 13-I), and the cost figures of Table 13J-III, an expected-kill cost curve for the Remote Air Battle may be obtained. This curve is shown in Fig. 13J-1.

D. Gillette
C.B. Moore

TABLE 13J-III						
SYSTEM COSTS						
Element	Low Level		Medium Level		High Level	
	No.	Cost (in millions)	No.	Cost (in millions)	No.	Cost (in millions)
New bases	2	$100	2	$100	2	$100
Improved bases	4	40	10	100	11	110
AEW aircraft (capital)	45	191	45	191	135	573
AEW (operating)	1.5 years	76	1.5 years	76	1.5 years	228
Interceptors (capital)	90	430	360	1720	540	2580
Interceptors (operating)	1.5 years	225	1.5 years	1000	1.5 years	1350
Arctic – United Kingdom barrier (capital)	8 stations	40	8 stations	40	8 stations	40
Arctic – United Kingdom barrier (operating)	1.5 years	12	1.5 years	12	1.5 years	12
Command administration and external support	–	156	–	544	–	798
Total		1270		3783		5791

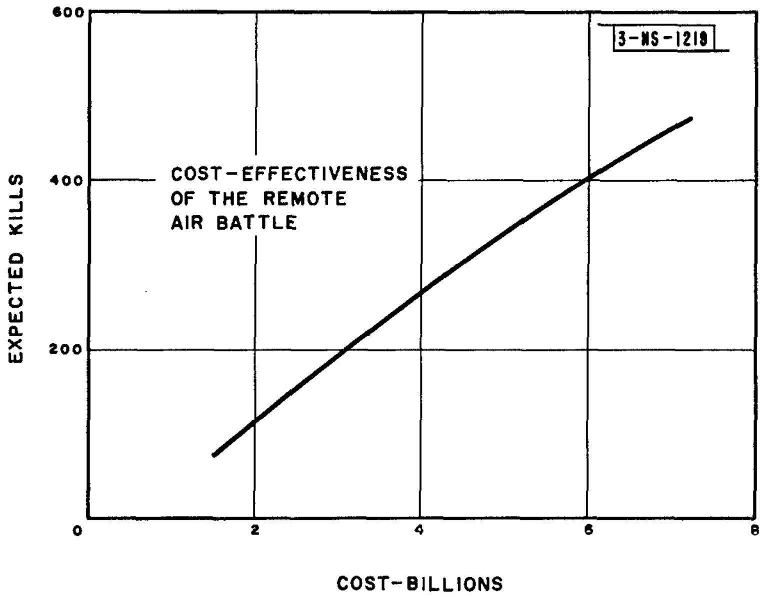

Fig.13J-1. Mass raid on northeast heartland; raid size at least twice the kills expected in the RAB.

APPENDIX 13-K

VECTORING LIMITS FOR REMOTE AIR BATTLE INTERCEPTORS

INTRODUCTION

In this appendix, an estimate is obtained of the vectoring limit for a weapon system with a speed disadvantage.

SUMMARY

Because of the long-range radar and missiles carried, and in spite of a possible speed disadvantage, the postulated RAB interceptor should be able to attack high-performance jet bombers from broadcast control. Even if the target-course line-of-sight angle reaches 60° when detection occurs at 100 miles, or 80° at 50 miles, conversion to attack will remain possible.

APPROXIMATE SOLUTION

The geometry for an approximate solution of the vectoring problem, involving a zero-time and zero-radius interceptor turn, a zero time-of-flight missile and a nonmaneuvering target, is given in Fig. 13K-1. I and T are, respectively, the interceptor and target positions, separated by a unit distance; r is the missile range in units of initial separation distance. B is the proper interceptor heading for intercept, relative to the line of sight between interceptor and target, and A is the target heading relative to the target-interceptor line of sight. S_1 and S_2 are, respectively, the speeds of the interceptor and target, $S_1 < S_2$ and d is the separation at time t.

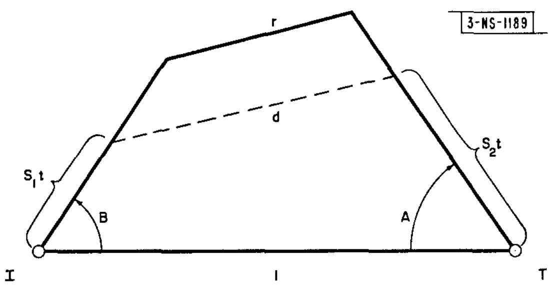

Fig. 13K-1. Geometry of approximate solution.

Let (x_1, y_1) and (x_2, y_2) be the positions of interceptor and target of the time t.

These coordinates are given by

$$\begin{aligned} x_1 &= S_1 t \cos B \\ y_1 &= S_1 t \sin B \\ x_2 &= 1 - S_2 t \cos A \\ y_2 &= S_2 t \sin A \end{aligned} \qquad (1)$$

Inserting Eq. (1) into the equation for the square of the distance between (x_1, y_1) and (x_2, y_2),

$$d^2 = [1 - (t)(S_2 \cos A + S_1 \cos B)]^2 + [t(S_2 \sin A - S_1 \sin B)]^2 \quad . \qquad (2)$$

Letting

$$V = S_2 \cos A + S_1 \cos B$$
$$W = S_2 \sin A - S_1 \sin B \quad , \tag{3}$$

we have

$$d^2 = 1 - 2tV + t^2 (V^2 + W^2) \tag{4}$$

if there is to be a d such that $d \leq r$ (i.e., intercept is possible). Then

$$(V^2 + W^2) t^2 - 2tV + 1 - r^2 \leq 0 \quad . \tag{5}$$

Since Eq. (5) is quadratic in t and concave upwards, it will yield a solution to the vectoring problem only if there is a solution to the equality obtained by setting the left side of Eq. (5) equal to zero. The condition for a real solution is then

$$V^2 - (1 - r^2)(V^2 + W^2) \geq 0 \quad , \tag{6}$$

or

$$r^2 V^2 - (1 - r^2)(W^2) \geq 0 \quad . \tag{7}$$

Equation (7) is satisfied if

$$rV - \sqrt{1 - r^2}\, W \geq 0 \quad . \tag{8}$$

Inserting Eq. (3) and rearranging terms, Eq. (8) may be rewritten as

$$S_2 (r \cos A - \sqrt{1 - r^2} \sin A) + S_1 (r \cos B - \sqrt{1 - r^2} \sin B) \geq 0 \quad . \tag{9}$$

Since $0 < r \leq 1$, for nontrivial solution we may let

$$C = \sin^{-1} r \quad . \tag{10}$$

Inserting Eq. (10) in (9), the condition becomes

$$S_2 (\sin C \cos A - \cos C \sin A) + S_1 (\sin C \cos B - \cos C \sin B) \geq 0 \quad . \tag{11}$$

Using a trigonometric identity and solving for B

$$B \geq - C + \sin^{-1} \left[\frac{S_2}{S_1} \sin (A\text{-}C) \right] \quad . \tag{12}$$

An upper bound for B may also be determined from Eq. (7). Referring to Fig. 13K-1, we see that satisfaction of Eq. (12) implies a solution to the vectoring problem. If we wish to find the maximum admissible angle A_o, we note that Eq. (12) is not satisfied if

the argument of the arcsin exceeds 1; since S_1, S_2 and C are fixed, this implies the condition

$$A \leq C + \sin^{-1} \frac{S_1}{S_2} \quad , \tag{13}$$

and yields the vectoring limit

$$A_o = \sin^{-1} r + \sin^{-1} \frac{S_1}{S_2} \quad . \tag{14}$$

In Fig. 13K-2, A_o is plotted against r for various values of the ratio S_1/S_2.

CORRECTION FOR INTERCEPTOR MANEUVER AND MISSILE TIME OF FLIGHT

While the above computations do not include consideration of realistic interceptor maneuvers and missile time of flight, the correction may be shown to be small for the situations expected to be encountered in the RAB. It may be shown that, for a 400-knot interceptor with normal load of 1.5 g's and a 2000-ft/sec missile, the error in the curves of Fig. 13K-2 never exceeds 10° – and this, only when the interceptor must turn 180° to make an attack. For less than a 45° turn (as may be expected under broadcast control), the error does not exceed 3.5°.

EXAMINATION OF FIGURE 13K-2

Having determined that the curves of Fig. 13K-2 are fairly indicative of the exact results, let us see how they apply to the RAB problem.

For a 25-mile missile, a 400-knot interceptor and a 500-knot target (S_1/S_2 = 0.8), it is seen from Fig. 13K-2 that, with detection at 100 miles (r = 0.25), the target may be heading up to 67° from the line of sight and still be intercepted. We also see that, as we close to 50 miles (r = 0.50), the

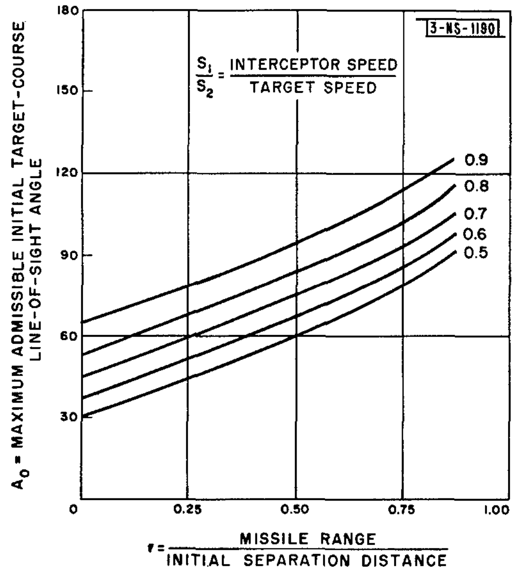

Fig. 13K-2. Approximate value of vectoring limit.

target must maneuver to some 83° from the line-of-sight in order to avoid attack.

One measure of the value of a long-range missile may also be seen from the curves. If the 400-knot interceptor has a 5-mile missile instead of a 25-mile missile, the admissible target-course deviation is reduced some 10°. Similarly, a 50-knot increase in interceptor speed increases the admissible target deviation by about 10°.

K.D. Gillette

[redacted]

DEPARTMENT OF THE AIR FORCE
WASHINGTON, DC

3 September 2008

HAF/IMII (MDR)
1000 Air Force Pentagon
Washington, DC 20330-1000

Department of the Navy
Naval Research Laboratory
ATTN: Vicki L. Cicala
4555 Overlook Avenue SW
Washington, DC 20375-5320

Dear Ms. Cicala

Your letter dated 9 January 2008, requesting a Mandatory Declassification Review of the following documents:

S30921 Final Report of Project Lamp Light, Vol I DTIC AD0311318
S30922 Final report of Project Lamp Light, Vol II DTIC AD0311319
S30923 Final Report of Project Lamp light, Vol III DTIC AD0311320
S30924 Final Report of Project Lamp Light, Vol IV DTIC AD0311321

The appropriate Air Force agency has reviewed the documents IAW the Executive Order 12958, as amended, and finds we have no objection to the declassification and release of the Air Force information.

Address any questions concerning this review to the undersigned at DSN 223-2560 or COMM (703) 693-2560 and refer to case number 08-MDR-040.

Sincerely

Joanne McLean

JOANNE MCLEAN
Mandatory Declassification Review Manager

1 Atch
Documents for Review (S)

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This page is UNCLASSIFIED when standing alone.